RESOURCE RISK AND ITS MITIGATION FOR THE FINANCING OF GEOTHERMAL PROJECTS

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ABSTRACT

The resource risk in connection with the financing of geothermal projects can be subdivided into questions of: resource existence, resource size, deliverability, cost of development and operation, environmental constraints, management and operational problems, and resource degradation. Except for the question of resource existence, these risks can change in perception, or in reality, over time. If resource risk cannot be managed or mitigated, it will result in increased cost, loss of revenue, or both, at times leading to economic failure and shutdown of the project. Costs accrue to the developer and the equity investors. In certain cases they can be passed on to lenders (default and rescheduling of payments), or to the public (increased power cost or increased taxes). This in turn may cause investors or lenders to shun future geothermal projects, or to increase the requirement for protective guarantees, with the result that future projects become more costly to finance, and thus less likely to succeed economically.

Several approaches have been tried by the financial institutions to mitigate resource risks; these can be summarized as the exercise of greater care by financiers in project selection and in disbursement of money, along with more careful monitoring of performance, and a willingness to take control of poorly performing projects. In order to mitigate or minimize the resource risks associated with geothermal project financing, lenders in the United States require verification of the geothermal resource, development plans, budgets and timetables, project structure and management, and environmental and regulatory issues. This verification is made periodically throughout the period when a substantial amount of capital is at risk.

1. INTRODUCTION

Commercial geothermal power generation in the United States started in 1960. Since then a total generation capacity of nearly 3,000 megawatts has been installed, and 400 megawatts of new capacity are to be added in the United States during the next few years (figure 1). These projects have been, and will be in the future, funded almost entirely through private financing. Because there is currently no government guarantee behind such projects in the United States, an early assessment of the project risks and their mitigation is required in order to satisfy the equity investors and lending institutions.

If risk can be defined as investment yet to be recovered, then figure 2 presents the risk profile for a typical but hypothetical geothermal project in the United States. The risk is transferred gradually from the equity investor to the holder of senior debt during the development stage of the project. After 15 to 20 years of commercial operation, the risk to the original investors could be considered negligible as all or most of the capital would have been recovered by then.

The risk in a geothermal project may be divided into several categories:

- Resource risk
- Market access and price risk
- Construction risk
- Organizational and management risk
- Legal and regulatory risk
- Interest and inflation rate risk
- Force majeure.

All of these except the resource risk are common to all other types of power projects; therefore, financial institutions are familiar with them and have developed mechanisms to assess and mitigate them. By contrast, geothermal resource risks, being relatively unfamiliar, have been the subject of intensive investigation in recent years in the United States, often as a condition of financing. This paper is a survey of the types of resource risks encountered in these projects, and their mitigation.

2. TYPES OF RESOURCE RISKS

The first risk confronting a geothermal project, during the exploration or initial drilling stage, is whether or not a commercial geothermal reservoir exists in the project area; the resource risk is at its highest at this stage. Until exploration, including drilling and initial well testing, has confirmed the existence of a commercial resource, no bank or financial institution will provide project financing (non-recourse loan). Therefore, exploration or initial drilling in the United States is financed by some combination of equity contribution, corporate funds, corporate loans and public power revenue bond issues, depending upon project ownership. Until about 10 years ago, all geothermal projects were financed this way from the exploration to power generation stage.

Even after a commercially attractive resource is discovered by geoscientific surveys and drilling, the size of the reservoir and the ability of the future wells to deliver the resource at commercial rates are not known with certainty. These perceived risks regarding reservoir size and deliverability may discourage financial institutions from offering project financing until a sufficient number of wells have been drilled and tested to demonstrate that the available reserves are adequate for the contemplated project, and that the wells will produce at commercial rates. If a successful commercial project already exists in an adjoining leasehold in the same field, typically only one or two "step-out" wells need to be drilled and tested successfully before the financial institutions will consider the resource risks acceptable for project financing. If the project is the first one to be developed in a field, typically 10% to more than 30% of the production necessary to supply the plant needs to be proven before project financing can be obtained; the higher the perceived resource risk the higher the required level of proven production. In addition, the banks may require proof that injection of the waste fluid from the power plant does not pose any problem, whether operational or environmental. Several projects in the United States have suffered delays, and a few have been damaged financially, because an effective injection program could not be designed, even though the needed production capacity had been developed in a timely manner.

Even after the reservoir size and well production and injection capacities are confirmed to the investor's or lender's satisfaction, significant uncertainty remains as to the capital outlay required for field development and the cost of operating and maintaining the steam (or hot water) supply to the plant from year to year. These uncertainties arise from the inherently heterogeneous nature of a geothermal reservoir. These risks are taken into account in the due diligence process for project financing, through the development of a range of cost estimates, and calculations of their impact on profitability and debt coverage ratio. Exceeding the budget for field development, or experiencing a higher field operations and maintenance cost than expected, has not been uncommon in the industry. This risk has become a significant concern to the lending institutions because of impact on loan repayment, especially in projects of high resource risk or lower than average projected profitability.

Another area of risk of significant concern to the financial institutions is the environmental or permitting constraint potentially associated with a new geothermal project. The development of a geothermal project at the Newberry Volcano area in Oregon, United States, has been delayed for several years because of such constraints. Other projects have suffered shorter but still significant delays or have been burdened with an unexpected environmental evaluation, monitoring or mitigation cost. The permitting process for an expansion of the generation capacity from 12.5 MW to 42.5 MW at the Long Valley geothermal field in California proved to be a major hurdle. As a condition of the permit, the developer had to commit funds to monitor, for the entire plant life, any potential impact of the increased production and injection on the local ground water system, and in particular on the spring supplying fluid to a local fish hatchery. In some projects, unexpected environmental issues have arisen after the field has already been developed and power generation has started. For these reasons, a significant part of the due diligence effort before project financing now consists of assessing environmental and permitting risks associated with the resource not only prior to or during field development, but also subsequently during power plant operation.

In a few projects, unexpected operational or management problems related to the resource have proven either to be unresolvable, or solvable only at a major cost to the project. Unlike the risk of higher-than-estimated operations and maintenance costs mentioned earlier, this risk is usually very small but can have a far greater cost consequence. This risk and its consequence on the operations and maintenance costs are more difficult to assess compared to the normal risk of resource degradation, in part because human factors of technical skill and management attitude are involved. In a few parts of The Geysers field in California (maximum installed capacity of about 2,000 MW), issues associated with corrosion in the wellbore and pipelines resulted in reduced project profitability, and have prevented further expansion of capacity. In one instance, management problems contributed to the bankruptcy of an operating company, with financial losses to investors, lenders and, indirectly, to the rate payers.

Finally, the resource risk most feared by the financial institutions is that of resource degradation. Most geothermal reservoirs degrade with production and injection: (a) the production wells in a geothermal project may decline in production rate and/or temperature (or enthalpy); (b) the injection pressure may increase; and (c) the chemistry of the produced fluid may change adversely with time as the project is operated. All of these have been experienced in various geothermal projects in the United States, with reduced profitability or even loss of capital. This possibility -- that the capital invested in a geothermal power plant and well field may become unrecoverable should the resource degrade prematurely -- is very troubling to financial institutions. These institutions are accustomed to lending to power projects where the fuel can be purchased from alternative sources. The exceptions to this are, of course, hydroelectric, wind power, solar and geothermal projects -- the so-called renewable energy projects.

This is one area of resource risk where quantification of the risk and an estimation of its cost consequence are theoretically possible, utilizing the predictive capability of numerical modeling. One can model on the computer the physical and/or chemical processes in the reservoir and/or well-bores in consequence of production and injection. However, forecasts from numerical reservoir modeling are reliable only when the model is calibrated against several years of production/injection history; the longer the available history the more reliable is the calibration. Often such models are calibrated only against the so-called long-term flow test data, which usually covers only a few weeks to a few months in duration. Therefore, the forecasts from these models may have substantial uncertainties of their own adding to the natural uncertainty of reservoir performance.

Numerical reservoir modeling has proven valuable in assessing the risk of resource degradation prior to financing expansions of existing projects, the production/injection history of the original project usually providing adequate calibration data. A typical example of this situation comes from the Salton Sea, East Mesa and Heber geothermal fields in California, where several plants were financed and built in succession, each phase of the project providing calibration data for the modeling of the next phase of reservoir development.

Cooling or enthalpy decline of the produced fluid is the most common resource degradation problem. There have been a few cases of reservoir modeling forecasts, based on inadequate production/injection history, that have underestimated the rate of cooling (or enthalpy loss) of the produced fluid, and that have resulted in significant financial damage to the project. Therefore, reservoir modeling is a useful tool, but not a panacea, in estimating the risk of resource degradation.

3. PERCEPTION AND CONSEQUENCES OF RESOURCE RISKS

These resource risks can be impacted favorably, or otherwise, by technological developments, changes in demand for electric power or in energy cost, government policies on energy, pricing, taxation or environment, and force majeure. That is, except for the question of resource existence, the other risks can change in perception or in reality over time. For example, a major hurdle in the development of the Salton Sea field in California was the perceived risk of in handling the hypersaline brine (about 8 times the salinity of sea water). A small experimental fluid handling facility was operated at Salton Sea in the early 1980s to investigate the fluid handling problems. A 10 MW demonstration project was subsequently operated in the Brawley field (also containing hypersaline brine) for several years to prove the necessary fluid handling technology. These demonstration projects facilitated the development of the commercial technology for the handling of hypersaline brine and sharply reduced the perceived technological risk. Power plants (totalling 231 MW) have been brought on line in this field over the last 10 years, each plant helping to further reduce the perception of the fluid handling risk. Today this risk is no longer an important consideration in project financing at Salton Sea, and a further 200 MW expansion of capacity is underway. Similarly, development of binary cycle technology has helped to change the definition of commercial geothermal resource, such that fields with temperatures considerably lower than 150°C have now become developable commercially, at acceptable levels of risk. Less than a decade earlier such resources would have been considered noncommercial for power generation.

Changes in energy pricing mandated by the government can have a major impact on the financier's perception of the resource risks. In California, a very attractive pricing formula ("Standard Offer 4") was introduced by the utility companies, at the direction of the State in fulfillment of Federal government legislative requirements, in the early 1980s. Suddenly, projects that were considered to have too high a resource risk (because of resource size or well deliverability or development cost or operational problems) became financeable. The intrinsic resource risks did not change; the risk perception did. For example, at the Coso geothermal field in California, as many as 8 drilling rigs were engaged simultaneously in drilling production wells for the successful development of 250 MW of electric generation in only 3 years.

Such a fast pace of field development implied little concern about drilling risks. In a typical project, the risks are reduced by drilling one or two wells, studying the drilling results, siting and designing new wells based on these results, then drilling a few more wells, studying the results again before drilling the next few, and so on. The lowered risk perception at Coso was due to a power sales contract attractive enough to justify the acceptance of a large "dry hole" ratio should drilling risks prove high, and a large number of make-up wells should the resource start degrading prematurely. The attractive Standard Offer 4 pricing ended in California a few years ago, and once again these same resource risks are proving to be the paramount concern of financiers.

Similarly, government policies on taxation or the environment have been known to change the resource risk perception, or rather the risk tolerance level, of the financiers. During the early 1980s, the U.S. government allowed certain tax credits for development of "new" energy sources, of which geothermal was one. This allowed financing of certain marginal projects; with the abolition of such tax credits, some of these projects would be considered to have too much resource risk to be financeable, that is, too low a financial return to justify taking the resource risk.

From the above discussion, it is apparent that resource risk perception of the investors and bankers is determined primarily by the potential cost consequence of the risk. If the resource risk cannot be managed or mitigated, it will result in increased cost, loss of revenue, or both, at times leading to economic failure and shut down of the project. If the cost consequences of the resource risk is relatively small compared to that of the other risks, or if the reward-to-risk ratio is sufficiently large, the resource risks appear negligible. For example, because of the attractive power sales price under Standard Offer 4, the drilling risks at Coso could be considered small compared to the anticipated reward. Conversely, plant construction risk suddenly became more significant, because the contract stipulated a very short-time deadline for the initiation of power generation as a condition of receiving Standard Offer 4 prices for power.

Increased costs due to unmitigated or unmanageable resource risks accrue to the developer and the equity investors. In certain cases the costs can be passed on to lenders (default and rescheduling of loan repayment) or to the public (increased power cost or taxes). This in turn may cause investors or lenders to shun future geothermal projects, or to increase the requirement for either a corporate guaranty or cash reserves to be built up from project revenues. Often such cash reserves are maintained in the form of a revolving account that is used to fund unforeseen operations and maintenance costs; as the project incurs such costs, the developer is required to replenish the reserves from its project earnings. The final consequence of these unmitigated resource risks is to make future geothermal projects more costly to finance, and thus less likely to succeed economically.

4. MITIGATION OF RESOURCE RISK

Many approaches have been tried in the United States to mitigate resource risk in geothermal projects, with varying success. Mitigation to lenders and investors can be achieved through some combination of:

- Ensuing that the field has been adequately explored before the development plans are made.
- Establishment of stringent or restrictive profitability criteria and for debt coverage ratio for a project. The higher the perceived resource risk, the greater are the required profitability criteria or debt coverage ratio.
- Careful selection of projects, with close attention to the prior experience and technical and management skills of the developer. Well-established geothermal developers and operators find it easier to finance a project than the relative newcomers to the industry, even if the resource risk is not perceived to be high.
- Careful, independent review of the development plans, prior to signing financial agreements. This review is intended to remove any optimistic bias in the plans, or any intentional or accidental downplaying of the risks.
- Stringent examination of the development and operational plans for the "worst-case" scenario. In the due diligence effort for financing, it is customary to consider the worst-case scenario to assess project profitability and the likelihood for adherence to a debt repayment schedule.
- Requirement of rapid and effective response to environmental, permitting and other regulatory issues related to field development that could impact upon development practice, timetable and cost. The potential adverse effects of environmental constraints on a project typically are built into the worst-case scenario.
- Design and implementation of a program of "milestones", relating to field development objectives and timetable.
- Conscientious use of numerical modeling to track well deliverability, resource quality and reservoir response, and to forecast reservoir and well responses under various available operations and management scenarios.
- Routine milestone review meetings, with mechanisms for ownership transfer or shutdown of the project in event of failure to satisfy milestone objectives. Salvage operations may also be designed as part of the worst-case scenario.
- Risk-sharing through increasing the number of investors or lenders in a project. In most geothermal projects, several banks may lend as a "club", or one bank may lead a loan syndicate, in which shares of the loan are apportioned to other banks after the loan has "closed".
- Risk-shifting by means of the purchase of insurance against various man-caused and natural failures, with a resulting increase in project cost. In the early 1980s, a few insurance companies in the United States expressed willingness to provide geothermal "reservoir" insurance; but the premiums required to cover the resource risks proved too high to attract commercial interest. The Federal government declined to subsidize such an insurance program, and no reservoir insurance is available today.

The above risk mitigation measures can be summarized as the exercise of greater care by financiers in project selection and in disbursement of money, along with more careful monitoring of performance, and a willingness to seize control of poorly performing projects. Fear by financiers of taking control of floundering projects increases the risk of project failure.

5. RESOURCE VERIFICATION REQUIRED BY THE LENDERS

In order to mitigate or minimize the resource risks associated with geothermal project financing, lenders in the United States require verification of the geothermal resource throughout the period when a substantial amount of capital is at risk (see figure 2).

Before the closing of the construction loan, typically the following resource verification steps are undertaken by the lender, typically through an independent third party.

- The resource data submitted by the developer are reviewed by the lender.
- Resource adequacy is assessed by the lender and the resource economics estimated.

- Project development and management risks are assessed and adequate risk coverage ensured by the lender. In the process, the lender may ask the borrower to modify the field development or management plan to reduce risk.

- The field development plan and budget proposed by the developer are reviewed, and agreed to by the bank, if reasonable. If not, a modified plan and budget are arrived at and agreed upon through discussion between the lender and borrower.

- All resource-related issues, technical, legal, managerial or financial, are resolved through negotiations between the lender and borrower before loan closing. A set of conditions are defined and included into the loan document to protect the lender from undue resource risks.

- Minimum resource criteria are defined by the lender as necessary conditions for passing the Acceptance Test underwhich the construction loan ultimately is converted into a longer-term project loan.

Once the construction loan agreement is in place, the lender monitors field development activities through the following steps:

- On-site inspection of various field activities are conducted by the lender during field development.

- The progress of field development is monitored by the lender continuously to ensure adherence to the resource development plan and budget, and certificates of compliance are issued to that effect periodically. Issuance of such certificates is a prerequisite to the periodic disbursement of funds by the bank to the developer under the loan agreement.

- Any unforeseen problem encountered during resource development is examined, and the developer's proposed plan of solution is reviewed and endorsed, if reasonable, by the lender. If the developer's solution is unacceptable, within the constraints of project schedule and budget, discussions are held with the developer to arrive at a plan acceptable to both the lender and borrower.

Once the field development and plant construction have been completed, the following steps are usually taken before the conversion of the construction loan to a term loan.

- The initial resource assessment is updated. If this update indicates a major limitation to the exploitation of the resource, the construction loan may be renegotiated to reflect the new reality.
- Resource milestones of the Acceptance Test are monitored by the lender; if the test fulfills the minimum resource criteria defined in the loan agreement, a legal certification of resource adequacy is issued. If not, the loan conditions and/or power sales contract are modified by the parties involved through negotiation.

- Any unforeseen resource-related problem experienced during the Acceptance Test is examined by the lender, and the developer's proposed solution is reviewed and endorsed, if found reasonable. If not, the lender and borrower negotiate a modified plan acceptable to both parties, and the term loan conditions may be renegotiated.

- Any other resource-related questions raised during loan conversion and bank syndication are resolved through discussion and negotiation between the lender and borrower. This may lead to modification of the term loan conditions.

Following the conversion of the construction loan, the project is monitored over the lifeterm of the loan through the following steps:

- Resource data are reviewed periodically by the lender.

- Continued resource adequacy is verified by the lender periodically.

- Any unforeseen resource management problem is analyzed, and the solution proposed by the borrower is reviewed and endorsed by the lender, if reasonable. If not, discussions are held to arrive at a mutually satisfactory solution within the confines of the loan agreement.

- Any proposal for expansion of the generation capacity or changes in resource management plan submitted by the borrower is reviewed by the lender. The plan is approved or the borrower is asked to modify the plan, depending on the specific situation and loan conditions.

The above resource verification procedure has the potential to minimize the exposure of the lenders to resource risk and to increase lender confidence in the commercial future of the geothermal industry.

Figure 1: Geothermal projects in the United States

Figure 2: Typical Risk Profile for a Geothermal Project