

PROFITABILITY ANALYSIS AND RISK MANAGEMENT OF GEOTHERMAL PROJECTS

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STARTING POINT

Bavaria is experiencing a boom in geothermal energy. While only a few claims had been staked in 2003, by the end of 2006, there were already about 75 exploration and exploitation permits for searching for hydrothermal sources of geothermal energy and exploiting them for district heating and/or generating electricity. The search for geothermal sources in the Molasse [a group of Miocene sedimentary deposits in the Alpine region] has turned out to be substantially more complex than originally suspected. The numerous technical, economic, and legal questions are only really coming into focus now that projects are to be implemented. In addition, the environment for heat and electricity projects has changed significantly in the past two years: thus, heat projects benefit from the increased prices of oil and gas, and from the concern over dependence on the classical energy media. On the other hand, all projects are suffering from the sharply increased prices of drilling and steel, and from the increased expense of purchasing electricity for auxiliary power requirements. The profitability simulations for municipal and private district heating and electricity projects agree that the leeway between a profitable and an unprofitable geothermal-energy project has become very small. From the point of view of energy and environmental policies, it would be worthwhile to exploit the Bavarian geothermal potential, since renewable sources of energy that are carbon-dioxide-free and can be used for base-load power are hardly plentiful. So there must be a focus on the economic aspects from the start of the project.

INVESTMENT AND FINANCING

For the profitability analysis, an electricity and a district heating project standardized for the Molasse region are considered. In the electricity project, a geothermal potential of about 38 megawatts is to be exploited by means of a triple geothermal well at a drilling depth of 3,500 metres, with an annual average generating capacity of about 4.5 MW being installed, using a Kalina cycle. In the case of the district heating project, a thermal potential of about 19 MW is to be utilized, at a depth of about 3,200 m, by means of a twin geothermal well, in order to provide a total connected capacity of about 35 MWt to heat customers when the expansion is complete, and supply about 66 GWh of heat, as part of a local district-heating scheme.

For the electricity project, investments of about € 33 million are required. The individual items of drilling and power plant alone account for 82% of the total investment. The financing volume whose structuring is to be optimized amounts to about € 40 million, since the planning expenditures (feasibility studies, seismic analysis, discovery insurance, etc.) and the negative cash-flow also need to be

financed. The banks apply very strict standards to this, not only with respect to the profitability analysis and coverage of the risks in the project. Depending on the discovery insurance concept, enough funds to cover most of the drilling costs, or about 25-30% of the investments in fixed assets, are regularly demanded. Obtaining these funds presents considerable difficulties, because of the decreased profitability of such projects (more on this below).

Division of electricity project investments.

Investment in fixed assets geothermal power projekt	€	in %
Drilling	16.400.000	50,15 %
Kalina cycle power plant	10.400.000	31,80 %
Cooling (conditioning & piping)	1.800.000	5,50 %
Buildings (plant & cooling)	1.500.000	4,59 %
Pumps, including stand-bay	1.800.000	4,89 %
Grid connection	200.000	0,61 %
Switchgear	300.000	0,92 %
Land	200.000	0,61 %
Outlying structures	300.000	0,92 %
Total	32.700.000	100,00 %

District-heating projects involve higher volumes of investment, unless an existing district-heating network can be used. In the example, they amount to about € 46 million, of which about 42% is accounted for by the distribution network, and 23% by the drilling. After the large initial expenses for drilling, the thermal-energy plant, and the basic network, the investments continue for the five to ten years of the network's enlargement and increasing density. The funds for financing must flow accordingly. Besides the investments, the planning expenses and the negative cash-flow during the phase of establishing the network, amounting to at least € 5 million, must be covered in this case, too. If only because of these initial losses, about 20% of a district heating project must be self-funded. Apart from this, district heating projects have been financed externally at low rates of interest, due to municipal guarantees for the loans. It remains to be seen to what extent and under what conditions this can still be done after the reform of EU rules on subsidies. Without a surety from the municipality, banks find it difficult to finance a district heating project as well, because of the uncertainties of discovery, drilling, and sales.

PROJECT PROFITABILITY

In the electricity project, proceeds of € 150.00 per megawatt-hour for supply to the grid under the Renewable Energy Act [Erneuerbare-Energien-Gesetz = EEG] are obtained for outputs up to 5 megawatts. In this example, annual electricity sales amount to about € 5.4 million. The main features on the expenditure side are service of the capital

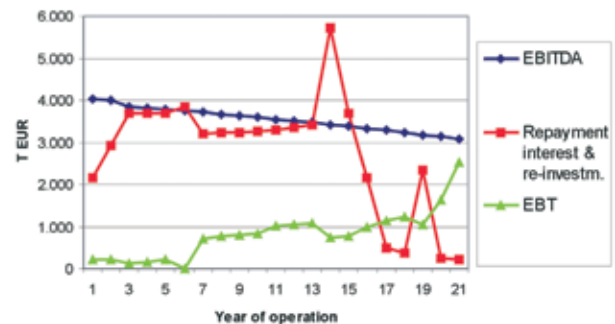
Division of district-heating project investments.

Investment in fixed assets geothermal district-heating project	€	in %
Drilling	10.400.000	22,61 %
Pumps & accessories	800.000	1,74 %
Geothermal station & equipment	2.100.000	4,57 %
Peak-load heating plant	800.000	1,74 %
Distribution network	19.500.000	42,39 %
Service connections	6.600.000	14,35 %
Heat-transfers stations	5.400.000	11,74 %
Land	400.000	0,87 %
Total:	46.000.000	100,00 %

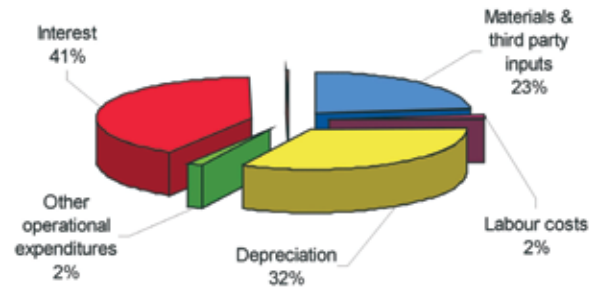
(depreciation and interest), and the material for station service power. Assuming a planning, construction, and commissioning phase of three years, an electricity project achieves the break-even point when “normal operation” commences in the fourth year (= first year of operation). In the diagram, this is shown by the fact that the EBT (earnings before taxes) curve is positive from the start. Because the payment for supply to the grid remains constant over the period of the project, the profits do not rise in the electricity project until the interest expense drops after installments have been repaid. Increasing electricity costs, which are to be expected, will cause a contrary trend. The declining EBITDA curve (earnings before interest, taxes, depreciation, and amortisation) is thus typical of electricity projects. The EBITDA is also an important parameter for bank financing, since it should always be significantly higher than the payment burden for debt repayment, interest, and re-investment, in order to ensure the long-term credit rating of the project. The closeness of the EBITDA curve to the financing payment burden during the first ten years of the project shows how difficult the financial situation of electricity projects is, at present. During the 21-year period of payment for supply to the grid under the Renewable Energy Act, the return on equity is only about 9%. This is not considered adequate in view of the project risks, so that it is difficult to acquire equity capital for geothermal projects on the capital market. The main reason for this poor financing situation is the costs of drilling, steel, and electricity, which have risen by up to 50% from those in 2004. Before this cost increase, marketable project returns of about 15% could be presented. In order to restore the promotion effect intended by the amendment of the Renewable Energy Act in 2004, the payment for supply of geothermal electricity would have to be raised to € 175-180 per MWh.

In the case of the district heating project, the sales are the product of the heating capacity provided in the network, the amount of heat sold, and the heat price rates applied. A natural limit is imposed on the price by the competing sources of energy oil, gas, wood chips, etc. And the rate scale must be designed so as to give an incentive to switch to geothermal heating. Here too, the

Earning parameters of electricity project



Total expenditure on electricity project



capital costs dominate the expenditure side. The expenditure on supplies, which is also significant, features, in addition to the operating power for the geothermal and network pumps, the energy inputs for peak-load, standby-load, and possibly intermediate-load supply. In contrast to the electricity project, in a district heating project it is not possible to break even upon commissioning. The EBT curve in the diagram shows that the break-even point can be reached after about ten years. During this lean period in the district-heating project, the EBITDA is also less than the installment, interest, and re-investment payments, so that the project can only be kept in a financial equilibrium by a single high input or successive inputs of equity capital. Because of the high starting losses, the (municipal) providers of equity capital obtain a return of about zero percent during the initial years of the project, and only about 6.7% over the thirty-year duration imputed for cost accounting. In contrast to electricity projects, district-heating projects have a rising EBITDA curve. The expansion of sales by means of increasing the density of the network only causes minor additional expenses for material, as long as the available geothermal output is substantially higher than the intermediate load. The heating utility therefore benefits from the economies of scale per MWh in labour, administrative, and other operating expenses as the volume of sales increases. In addition, there are the economies of scale for depreciation and interest, which are reflected in a considerable increase in EBT. However, all this presumes that the prices for close-by district heating will rise moderately over the longer term, in our example by about 2.7% per annum. Without price increases, district-heating projects do not reach the break-even point at present. Prices for geothermal heat that cover costs from the start are not (yet) competitive at this time. The utility can profit from the assumed rise in the prices of compet-

ing sources of energy by an appropriate structuring of the escalation clause, while limiting the effect of this rise on the customer. In this way, both parties benefit. It will be necessary to make sure that the prices of geothermal heat increase only moderately in the longer term, so as to provide a continuing incentive to utilize this practically CO₂-free source, and not force the customers to insulate more thoroughly or lower their room temperatures for budget reasons. Such negative quantity effects would endanger the profitability of the project for the utility again. If oil and gas prices continue to increase substantially in the next few years, the starting conditions for geothermal district-heating projects would improve considerably, due to the higher initial sales prices for heat.

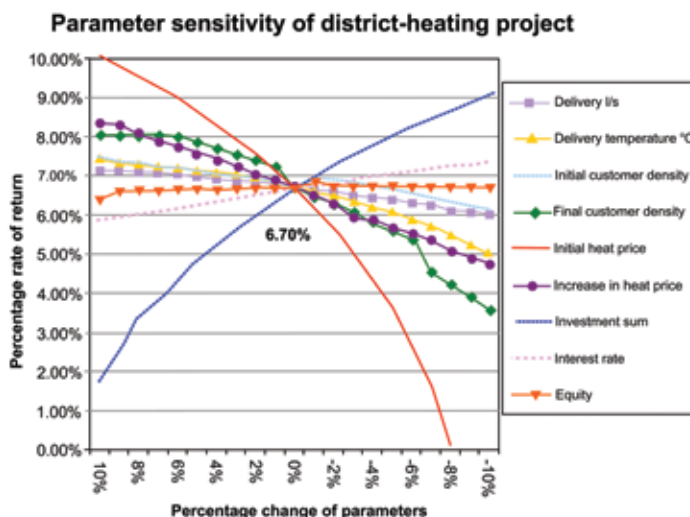
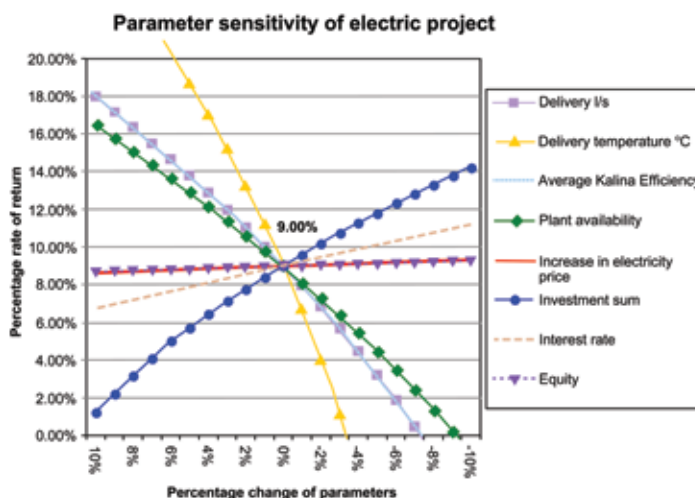
CRITICAL PARAMETERS – SENSITIVITY ANALYSIS

In order to evaluate the sensitivity of the profitability of such projects to changes in the relevant parameters, a comprehensive project simulation, with more than fifty geological, technical, and management variables is employed. The results are shown in separate diagrams for the electricity project and the district-heating project. The project profitability is shown on the Y axis, and the parameter variations in steps of one percent from +10% to -10% on the X axis. The steeper the curves shown are, the more strongly the project reacts to even small changes (other things being equal).

In the case of the electricity project, the initial return on investment is 9%. A reduction of the delivery temperature by 4%, of the discharge rate or the efficiency of the power station by 7%, of availability by 10%, or an increase in total investment by 10% suffice to make the project unprofitable (zero rate of return). The development of electricity prices, the costs of borrowed capital, and the debt-equity ratio are at least not critical for the project.

The case of the district-heating project presents a different picture. The initial return on investment is 6.7%. A reduction of the price for heat by 8% or an increase in the invested sum by about 12% make the project unprofitable (zero rate of return). A reduction in the final density of customer service connections by 10% also has a strong effect. The reduced heat sales lower the rate of return to about 3.5%. The other parameters, on the other hand, are at least not critical to the project in this example.

The point to keep in mind is that the underground operational factors, namely the richness of the field, drilling technology, and drilling costs are decisive. Even slightly less rich discoveries make an electricity project unprofitable. Since excess drilling costs, i.e. investments, reduce the return on an electricity or district-heating project substantially, particular attention must be paid to the planning of the drilling, the selection of the drilling company, and so on. Insurance coverage for this aspect would be desirable (see the following section).



RISK AND THEIR MANAGEMENT

The sensitive response of the project's rate of return to changes in the parameters of the computer simulations makes it clear that geothermal projects are financially risky. For one thing, every project faces the usual business risks, such as budget over-runs, increases in interest rates, delays, etc. The classical instruments of project management must be used to limit these risks. The initiators of the project must run profitability simulations in order to analyse varying scenarios before implementing the project, and update the results as the project progresses. Reserves must always be planned for in the financing. Business risks can also be limited further by suitable structuring of the contracts with the partners in the project (drilling companies, power-plant supplier, civil-engineering companies, et al.).

When the project is implemented, its initiators first bear the drilling risk, that the drilling company will not achieve the objective at all, or not within the time predicted, and thus within budget, or that the well proves not to be usable for pumping the thermal water. Part of this risk can be passed on to the drilling company in the contract (e.g. by means of turnkey contracts, instead of the usual day-rate contracts).

But the fact must not be overlooked that such a displacement of the risk, if possible at all in the conditions prevailing in the drilling market, will result in considerably higher drilling costs in the tenders. What strategy is promising must be decided from case to case. It remains to be seen whether it will be possible to insure against the drilling risk. Marsh, the insurance broker, informs us that the drilling risk will at least in the future be covered in “his” comprehensive geothermal policy.

The geological risk (non-discovery, partial or other discovery) is the main risk of an electricity project. It can be reduced by reprocessing old seismic analyses and preparing new ones. The remaining risk must be covered either by equity capital or by a “discovery insurance” policy. This form of insurance is not yet generally available. As far as we know, upgrading measures for wells have been insured by Munich Re-Insurance (Münchner Rückversicherung). The approach chosen by the author, in collaboration with Swiss Re, is aimed at comprehensive insurance of both the thermal potential to be utilized by means of the well, and also the absorption capacity of the injection wells and any upgrading measures.

Because of the still insufficient data available, a relatively high premium of 5% to 20% of the net drilling costs – depending on the site-specific risks – must be paid for this “comprehensive discovery policy”. In addition, there are the engineering and operating risks related to the generating station and/or the district-heating network. There are standardized insurance solutions to the classical operating risks. And, as for any other major facility, particular attention must be paid to the know-how of the planner and/or the plant manufacturer.

Specifically for the generating stations, the project initiators will demand a guarantee of plant availability and quantities of electricity generated for the first years of operation, backed up by securities from the manufacturer. In order to deal with the financial risks of a failure of the delivery or injection pumps, almost all projects have begun to keep standby pumps for themselves, or in combination with neighbouring projects.

LEGAL ASPECTS

The typical questions of contract, tax, and company law form part of the background of every successful geothermal project. Unnecessary burdens should be avoided, and arrangements made to ensure conflict-free project management, especially if several initiators are collaborating as partners or shareholders. This applies both to private consortia and to intermunicipal geothermal projects, with their necessarily diverging local needs and financial leeway. Particular attention must be devoted to the project and contract structures in the case of public-private partnerships, such as if private exploration and municipal construction and operation of the piping network are to be linked via a long-term district-heating contract. That the major investments in drilling, power station, etc. require a

suitable contractual basis has already been mentioned. When acquiring the plots of land and running the pipelines, one must make sure that the utility obtains a permanently secured legal position. The structuring of the price scales for the district-heating projects takes place in a medley of energy, contract, and anti-trust law, and forms the essential basis for the financial success of a district-heating project. It should also be mentioned that the municipal projects are subject to the regulations governing awards of public contracts and EU rules on subsidies. Of course, questions of mining law, from the application for an exploration licence to the exploitation licence and the official monitoring of well operation, also play a role; and the necessary permits for building and operating the power plant, including the cooling process, are also needed.

CONCLUSIONS

In the Molasse region of southern Bavaria, especially in the greater Munich region, favourable prerequisites for geothermal district heating and/or power generation exist in principle. Project initiators can rely on support from competent contacts for geology, engineering services, business concepts, and legal arrangements in the manifold technical, commercial, and legal challenges. Furthermore, one can hope for further engineering developments of the Organic Rankine Cycle (ORC) and the Kalina cycle in the relevant temperature range of 110°C to 140°C.

The sensitivity analyses show that changes in efficiency or generating-plant availability have a substantial positive effect on a project's profitability. Pumping conditions can also be improved. A District Heating Act governing input of heat generated from renewable sources of energy into the grid is provided for in the agreement establishing the current Christian-Democrat/Social-Democrat coalition government; its concrete structure is currently under discussion, and a draft bill is expected in the medium term. Evaluation of the Renewable Energy Act and its amendment, including the payment rates, is pending. A “deep-well bonus” for locations at which it is necessary to drill to unusual depths to exploit geothermal heat is also being discussed. The projects in the Molasse region would benefit from this. Increased subsidies for innovative concepts, such as hybrid ones, is also possible. Therefore, there is no reason for pessimism, despite all the financial difficulties and risks of geothermal projects described. The utilization of this very promising source of energy is only beginning.

ACKNOWLEDGEMENT

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