MODELING THE IMPACT OF RESOURCE AND ECONOMIC CONDITIONS ON THE COMPETITIVENESS OF MODERATE TEMPERATURE GEOTHERMAL ENERGY RESOURCES

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INTRODUCTION

The cost of energy from moderate temperature geothermal resources and the relative attractiveness of resource development to potential entrepreneurs will vary greatly on the basis of the specific resource and economic conditions. Substantial transport and distribution costs for direct application projects dictate that users be located as near to the resource site as possible, and they be concentrated in a relatively small area. This has important implications: while developers of other resources may view the entire nation, or large portions of it, as a potential market, the developer of a direct application geothermal resource faces a radically limited market. Thus, the constraints on this market make rapid penetration very important. Optimally, a geothermal developer will capture 100% of the relevant market before committing capital. This situation is, however, unlikely to occur. A gradual market penetration is likely to be the norm. This issue becomes a central point in successful geothermal development.

This paper analyzes what different rates of market penetration yield in terms of finances, and what flexibility the entrepreneur has for inducing higher rates of market penetration. Analysis is conducted through an economic model specifically designed to calculate the impact of changes in economic and resource conditions. The model fills a gap between the very detailed economic engineering models and those designed to estimate costs under very general conditions.

To analyze the specific resource and economic factors which, in large part, determine the attractiveness of geothermal energy development, the Center for Metropolitan Planning and Research (Metro Center) of the Applied Physics Laboratory (APL) of The Johns Hopkins University have developed an economic accounting model. It produces two decision variables - the Net Present Value (NPV) (defined below) and the "discounted average cost." The model can estimate the prospects of a geothermal development for industrial applications or for any residential area which has hourly temperature data available. After a brief description of the model, some preliminary results on the significance of different rates of market penetration follow.

THE MODEL

The Geothermal Resource Interactive Temporal Simulation Model (GRITS) calculates the cost and revenue streams over the economic life of an hypothetical, direct application project. Because projects will differ in terms of resource conditions, the user of GRITS may specify the following resource conditions:

1. production well depth
2. reinjection well depth
3. wellhead water temperature
4. average drawdown in the well when the utilization system reaches capacity
5. maximum flow rate from the well at full pumping.

Values for the well head temperature, drawdown, and flow may be specified as constants or as time dependent functions. The inclusion of time dependent functions permits additional flexibility, in that the user may specify changing resource conditions over the project's life.

For the residential subroutine, the user-specified economic parameters (either constants or time dependent functions), include the following:

1. type of housing units within the community heating system's service area;
2. percentage of housing units within the service area which eventually join the system;
3. cost per mile of installed distribution system;
4. geographic area and hence the heating demand of the housing units in the system;
5. system design temperature at which the peaking system begins operation;
6. cost of oil purchased for the boilers;
7. cost of electricity purchased to operate the downhole pumps;
8. price of energy sold to system customers (this value is bypassed in calculating the discounted average cost measure);
9. inflation rate (used to discount the real value of the nominally uniform debt service payments);
10. inflation-free discount rate;
11. rate of return paid to project investors (debt or equity);
12. rate of market penetration (always time dependent); and
13. project evaluation period.

The industrial subroutine treats resource conditions in the same manner as those in the residential subroutine. However, the industrial utilization level replaces economic parameters related to weather dependent heating demand, the density of users, and the rate of hookups to the system.

For a geothermal project with specified resource and economic conditions, GRITS calculates two economic measures of competitiveness: the Discounted Average Cost (DAC) and the Net Present Value (NPV). The DAC is defined as the uniform real product price which allows the project to break even by the end of its economic life. Its cost allows the decision maker to compare the costs of different energy sources or projects.

NPV is the difference between the discounted cost and revenue streams. The entrepreneur can use NPV for effective decision making; he may want to determine the effect, for example, of faster market penetration rates. The difference in NPV between two projects, identical except for the rate of market penetration, indicates the value of the higher rate to the developer. Based on this difference, the entrepreneur could achieve higher rates of market penetration by offering financial inducements to potential customers.

PRELIMINARY RESULTS

While GRITS can comprehensively address a wide range of resource and economic conditions, this analysis concentrates on preliminary results involving the significance of different rates of market penetration and the opportunities for the entrepreneur to induce higher rates of market penetration.

Since this sensitivity analysis involves only a few parameters, the default values chosen for the remaining parameters necessarily qualify the results. Because of this, a brief digression to outline these noneconomic default values follows. Housing includes densely packed, single family homes, rowhouses and garden apartments in a midsized town w which typifies the Mid-Atlantic resource area. The resource consists of a 5,500 foot well with reinjection to the production aquifer. The water level falls an average of 20 per cent once the well operates at full capacity. The maximum flow rate from the well is 500 gallons per minute and the well head temperature of the water is 160° F. Oil-fired residential furnaces are assumed 70 per cent efficient, while geothermal heat is assumed to be 90 per cent efficient.

Economic default values give fuel oil (geothermal energy price is tied to this level) a cost of $5.00 per million Btu's at the start of the project evaluation period, rising at an annual real rate of 3 per cent. The project has a 20 year economic life and inflation averages at 7 per cent per year. Funds are borrowed at 12 per cent and the discount rate is 2 per cent. The market saturation occurs when six out of ten households within the system's service area are connected.

Direct application geothermal systems, because of high capital intensity, necessarily incur proportionately high fixed costs, which occur regardless of the system utilization level. Higher utilization levels yield higher NPV's, making the project more attractive. Higher utilization results from more rapid market penetration.

Preliminary results include two cases of market penetration, chosen from expository purposes only. The first case consists of an initial 20 per cent market penetration and, by the 13th year, saturation is achieved. As shown in Figure 1, the project shows its first positive cash flow in the third year when the discounted revenue stream exceeds the discounted cost stream.

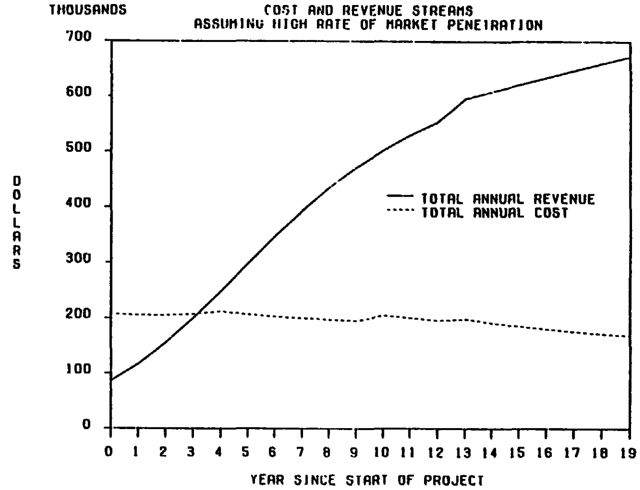

Fig. 1. Cost and Revenue Streams Assuming High Rate of Market Penetration

The second case assumed that eight per cent connect in the initial year and the system reaches the saturation level by the 17th year. In this case, the discounted revenue stream exceeds the discounted cost stream after the fifth year of operation.

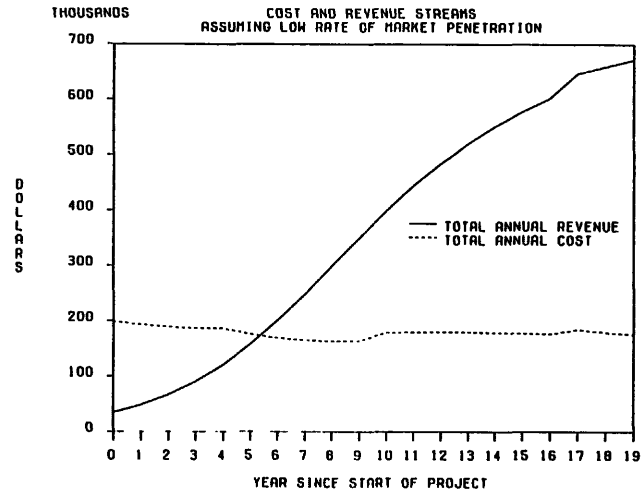

Fig. 2. Cost and Revenue Streams Assuming Low Rate of Market Penetration

The area between the two curves, shown in Figure 3, represents the monetary value of the higher rate of market penetration of the first case over the second. Until now this analysis has not addressed the reasons as to why the market penetration might differ for the same project. There is some basic rate of market penetration for any project determined by conditions such as furnance fatigue, new construction, and passive marketing as well as the premium attributes of geothermal heating.

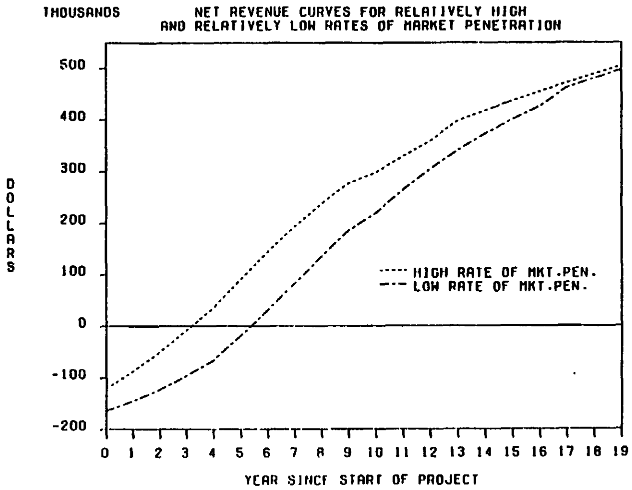

Fig. 3. Net Revenue Curves for Relatively High and Relatively Low Rates of Market Penetration

These two examples assume that the rates of market penetration occur without cost to the developer. It is evident, however, that most existing housing has serviceable heating systems already and that current owners would have to be "bought out" of their existing furnaces. These inducements are likely to be quite expensive (a preliminary study yields an average of $500 per customer), and reflect legitimate allocations of funds that must be included in any accurate characterization of the true costs of introducing geothermal energy. Research on the proper modeling of these inducements is currently being conducted, but it is clear that their omission biases the profitability estimates substantially upward.

CONCLUSIONS

At this time only limited analysis of the sensitivity of production costs and the financial attractiveness of moderate temperature geothermal resources has been conducted with the GRITS model. The model is highly interactive and the large number of variable parameters facilitates detailed sensitivity analysis. It is simple to operate and inexpensive to run. Although any mathamatical model is a highly stylized representation of the real world, GRITS helps to provide insights into the impact of specific resource and economic conditions on the economics of residential and industrial direct applications of geothermal energy. The preliminary analysis described above indicates one area of inquiry in which the model can provide useful insights.

REFERENCES

Weissbrod, R., and Barron, W., 1979, A review of recent energy price projections for traditional space heating fuel 1985-2000, The Johns Hopkins University APL: Laurel, Md.