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Industrial Application of Geothermal Energy in Lewes, Delaware: An Economic Analysis

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ABSTRACT

A major industry in Lewes, Delaware could realize substantial cost-savings through the substitution of geothermal energy for fossil fuel. A group of private investors has agreed to assume the responsibility for extracting and distributing the energy obtained from a proposed geothermal well in Lewes, Delaware. The U.S. Department of Energy is providing financial assistance for confirmation of this low temperature hydrothermal resource on the Delmarva Peninsula. The economic cost of supplying geothermal energy to the end-user based on existing preliminary data is presented using the GRITS computer simulation model. A brief sensitivity analysis gauges the impact of various alternate resource and financial conditions representing current areas of uncertainty.

INTRODUCTION

A major producer of pharmaceutical antacids is located in the coastal town of Lewes, Delaware. A geothermal well located a short distance from the plant may be able to provide energy for process heat, space heat, and sanitary hot water. Substituting geothermal energy for fossil fuel could constitute a substantial cost-savings for the firm.

Utilities and investors hesitate to become involved in resource development and energy distribution projects in cases where the resource is unproven. The geothermal resource in Southern Delaware has not been tested extensively. In order to gather detailed information about the geothermal aquifers and other geologic/hydrologic data about the Delmarva Peninsula, the U.S. Department of Energy is in the process of finalizing a cooperative agreement with the Delaware Energy Office to extend financial assistance in the drilling, testing, and completion of a proposed well in Lewes, Delaware.[2] This monetary assistance serves to encourage the involvement of utilities and private investors in geothermal energy extraction and distribution projects by reducing the risks that they would face.

The circumstances surrounding the Lewes, Delaware drilling project are complex. This is the first attempt to utilize a deep exploration well for commercial production of geothermal energy in the East Coast. For this reason I first present an explanation of the principals involved. Discussion of the economic model employed in this analysis and the sensitivity analysis that was conducted follows. The last section presents conclusions that can be drawn from the currently available data.

THE PRINCIPALS

Economic feasibility of direct applications of geothermal energy is highly dependent upon annual load factor, temperature requirements of the user, and the transport distance between the user and geothermal well site. The Barcroft Company plant in Lewes, Delaware is particularly well suited to utilize the energy from the low-temperature Delmarva Peninsula geothermal resource in that the firm conducts continuous processing during 11 months of the year, has relatively low temperature heat requirements, and has a physical plant that is situated in close proximity to the proposed well site.

Barcroft, a subsidiary of the William H. Rorer Corporation, processes pharmaceutical antacids. Geothermal energy could provide process heating for magnesium hydroxide and aluminum hydroxide gel production, sanitary water heating, and space heating for the warehouse. Barcroft will negotiate with the private investors for purchase of the geothermal energy once the reservoir characteristics, the productivity of the well, and the water composition have been determined by extensive well

[1] I wish to thank Peter Kroll, Julia Cohan, and Allen Goodman for their invaluable assistance in preparing this paper. I retain sole responsibility for any errors.

[2] Due to the sensitive nature of on-going negotiations, detailed organizational task descriptions and names of principals have been withheld.

Pertinent information was gathered during personal communications with representatives of the Barcroft Company, Delaware Energy Office, Ebasco Services Inc., and the group of private investors, all of whose help is greatly appreciated.

testing. Negotiations also include leasing the Barcroft land that will serve as the well site.

A group of private investors will coordinate the end-use of the energy by Barcroft and the confirmation drilling project sponsored by the U.S. Department of Energy (DOE). The private investors were approached to develop the resource and to purvey the energy after the local utilities declined to commit themselves. Both the municipal utility and the investor-owned regulated utility cited financing problems, the project's relatively high risk and an unwillingness to devote the necessary managerial effort. The private investors have prior experience in resource development and raising capital for risky enterprises. For this project, they will also be supplying services to the user and demanding services from the confirmation well drilling personnel.

In support of its goal to promote geothermal commercialization, DOE is providing monetary assistance of up to $800,000, to aid in the drilling, testing, and completion of the Lewes, Delaware well. This support is designed to reduce the drilling and exploration risks inherent in resource confirmation.

The main state agencies involved in the drilling project are the Delaware Energy Office and the Delaware Geologic Survey. The Delaware Energy Office is the state organization which has contributed inkind services to locate the well, to choose a purveyor of the resource, and to administer the DOE funds. The Delaware Geologic Survey has provided the drilling project personnel with the most current geologic information pertaining to southern Delaware and will collect and interpret all drilling samples for the state. The need for direct subsurface geologic information for southern Delaware will be satisfied by the data from the Lewes well (Ref. 2).

ECONOMIC MODELING OF THE PROJECT

The GRITS (Geothermal Resource Interactive Temporal Simulation) computer simulation model (Ref. 3) provides preliminary economic evaluation of district heating and industrial application projects. The model calculates annual revenue and cost streams throughout the life of the project to determine the delivered cost of geothermal energy. The two main economic accounting measures used to evaluate the project are the discounted average cost (DAC) and net present value of revenues less costs (NPV). The model was formulated to allow maxiumum flexibility on the part of the user in tailoring the resource, demand, and financial conditions to fit precisely the project under consideration. The temporal simulation character of the model allows the effects of changes through time of many of the parameters to be captured in the analysis.

Evaluating the cost of delivering geothermal energy to the Barcroft company using GRITS entails specification of plant annual utilization factor (a percentage of the total number of hours in a year) and transmission distance from the well site to the heat exchanger. Well cost estimates and heat exchanger cost estimates are specified along with reservoir and financial characteristics. The values selected for this basecase scenario are listed in Tables 1 and 2.

Table 1. Basecase Values for Resource Conditions

Production Well Depth	5000 ft
Reinjection Well Depth	3000 ft
Wellhead Temperature	121 °F
Reinjection Temperature	85 °F
Flow	250 gpm
Initial Drawdown (pct. of well depth)	14.89 %
Last Year's Drawdown	25.60 %
Transmission Pipe Distance	.019 mi
Resource Assessment	
Duration	1 yr
Cost	$50,000.00

Table 2. Basecase Values for Demand and Financial Conditions

Industrial Utilization Factor	100 %
Project Lifetime	10 yrs
Interest Rate	10 %
Discount Rate	4 %
Inflation Rate	9 %
Electricity Cost	5.58 ¢/kwh
Annual Change	5.00 %
Fossil Fuel Cost	7.00/MMBtu
Annual Change	4.00 %
Capital Equipment Lifetimes	
Wells and Pipelines	30 yrs
Pumps	1 yr
Heat Exchanger	10 yrs
Operation and Maintenance (pct. of capital)	1.5 %
Selling Price (pct. of fossil fuel price)	75 %

The investors are responsible for wells, pumps, transmission line, and heat exchanger. Barcroft expects to install a closed circulating system running from the well heat exchanger to the processing facility heat exchangers; in this way the processing of pharmaceutical quality antacids is protected from contamination.

The investors currently assume that the water quality will resemble that found at Crisfield, Maryland necessitating reinjection into a permeable sand aquifer, rather than surface disposal. Reinjection would take place at 3000 feet. This project is viewed by the investors as being of medium risk. To reflect this, the discount rate was set equal to 4 per cent. The expected rate of inflation during the next ten years was set equal to 9 per cent. The real rate of interest as indicated by long term bonds and taking into account risk factors for debt and equity holders was placed at 10 per cent. The project life of 10 years is short as compared with other geothermal projects. However, the resource is currently unproven. Another consideration is that reservoir depletion insurance premiums are guaranteed for a maximum of 7 years of the project life with a renewal option.

On the basis of this basecase scenario, GRITS calculates the cost of supplying geothermal energy to Barcroft as $6.30 per million Btu (MMBtu) in constant 1980 dollars. Net present value of revenues less costs at the end of ten years is equal to $56,000. Payback, when the cumulative savings from operating the geothermal system in lieu of burning fossil fuel surpasses the initial capital cost of the system, is achieved in year 3. Cumulative net revenues are positive starting in year 4. Total discounted operation costs saved by substituting geothermal energy for fossil fuel is $2,829,000.

SENSITIVITY ANALYSIS

A sensitivity analysis was performed to check the assumptions about risks borne by the investors due to the uncertainty about reservoir characteristics and financial estimates. Alternate scenarios were created to represent increased risk reflected in increased discount rates, selected well depth taking into account composition of the brine, and substantially increased costs above original estimates of well costs and electricity prices.

Risks present during exploration and testing of the well will be minimized by DOE's participation and by a grant of $800,000. The basecase scenario was changed to add $800,000 to the well costs. Both DAC and NPV were extremely sensitive to this change. The DAC increased by more than $2.5/MMBtu and the net present value was -$799.948. Clearly, without the DOE support the venture would not be profitable enough to support the exploration and testing required for resource confirmation.

Once the project is on-line, the well may lose productivity (through loss of pressure or temperature declines) faster than anticipated on the basis of the drilling test results. In that case, project viability would be reduced and possibly ended due to resource inadequacy. Discount rates were parametrically varied from 0 to 8 per cent to capture this risk. Due to the short project lifetime, i.e. 10 years, the DAC was insensitive to changes in the discount rate increasing by less than 2¢/MMBtu with a discount rate of 8%. However, the NPV drops from $105,000 to $23,000 over this range.

The water quality may dictate treatment prior to being sent through the transmission line to the heat exchanger. Figure 1 describes four possible cases: brines that were either slightly or highly corrosive, with and without a reinjection well. The most favorable case entails no reinjection and no treatment. It is also possible that the water requires treatment to pass through the surface piping but then will be sufficiently clean to be disposed of in the Bay, carried through by Barcroft's piping. The basecase scenario covers the case where a reinjection well is required with no extra treatment of the geothermal fluids. The worst possible case is represented by highly corrosive brines requiring both reinjection and treatment. In no case does the extra treatment raise the DAC significantly. Water treatment costs were simulated by increasing operation and maintenance costs plus the heat exchanger costs by 40 per cent. Compared with the well costs and electricity costs, the added costs incurred by installing and running the water treatment facility were insignificant.

Each of these four cases was plotted against several alternative well depths. Temperature changes occuring with increasing depth were noted; these are based on the thermal gradient measured by VPI from a shallow well and extrapolated for depths greater than 1000 feet. The tradeoff between the increased well costs and greater economy due to temperature increases causes the DAC to dramatically decline up to 4000 feet. Beyond 5000 feet the gains from increased temperature are outweighed by well costs and additional pumping requirements.

Similarly, the NPV shows significant increases up through 5000 feet. Beyond 5000 feet the additional pumping requirements and well costs compensate for the increased temperatures as shown by the reduced rate of NPV increases. Beyond 6000 feet there is no advantage in drilling a deeper well. A well more shallow than 4000 feet without a reinjection well and 5000 feet with a reinjection well drops the NPV below zero.

The absence of a reinjection well accounts for a decrease in DAC of at least $1.00/MMBtu and an increase in NPV of approximately $600,000. This points out the financial advantages to surface disposal.

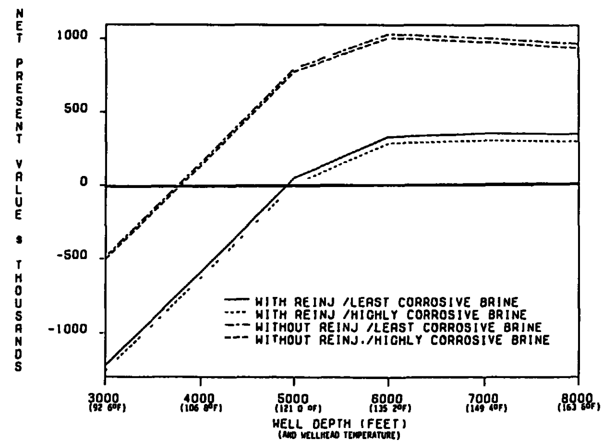

Fig. 1 Net Present Value as a Function of Well Depth for Cases of Slightly and Highly Corrosive Brines

A major source of concern is cost underestimates. This was analyzed by increasing the well costs, the most expensive capital component of the system, and increasing the real rate of electricity price increases. DAC increased by $.25/MMBtu for each 20 per cent increase in well costs. As shown in Figure 2 increase in well costs should be interpreted as being critical since NPV becomes negative with an increase in well costs of only 10 per cent.

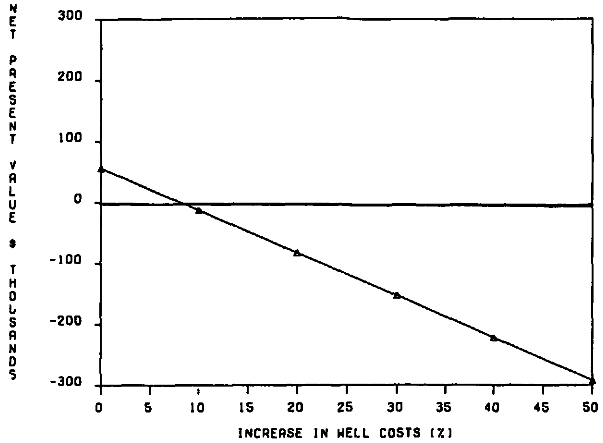

Fig. 2 Net Present Value With Higher Well Costs

The investors have also expressed concern about electricity price increases. The analysis is shown in Figure 3. The worst case originally considered by the investors was used in the base-case scenario and calls for a real rate of electricity price increase of 5 per cent compounded annually. If this is increased by 1 per cent the DAC rises by 4 per cent and NPV decreases from $75,000 to $20,000, a decline of $55,000. Each per cent increase above 6 per cent creates increasingly stronger responses by both DAC and NPV. This can be critical to the investors since annual increases in prices above 6 per cent cause NPV to become negative.

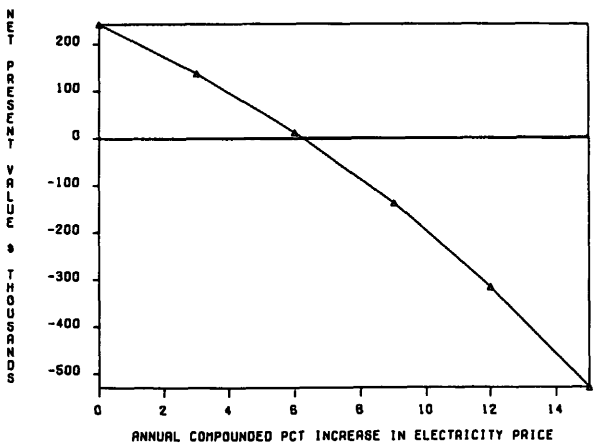

Fig. 3 Net Present Value Vs. Real Rate of Increase in Electricity Price Compounded Annually

CONCLUSIONS

The venture undertaken by the investors, to extract and sell the energy from the geothermal well, will yield a positive return based on the preliminary data incorporated in GRITS. The economic accounting measures, DAC and NPV, are not sensitive to changes in the discount rate; this is due to the short project lifetime under analysis.

If treatment of the water is required, the costs incurred would be minimal compared to those of increased well costs and annual compounded percentage in electricity prices.

Using currently available data the model results suggest that without DOE support, the project would not be undertaken. It should be kept in mind that there are many additional benefits to be gained from the successful drilling project other than resource confirmation. The DOE grant would promote development of an alternative energy source whose technology is well proven, supply needed geologic and hydrologic information, encourage dialogue between utilities/investors and potential geothermal users in addition to minimizing the risk occurring during resource exploration.

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