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ESTIMATING GEOTHERMAL MARKET PENETRATION

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ABSTRACT

In the forecasting of future geothermal energy use, account must be taken of resistance to conversion. One way to do this is to consider geothermal to be a competitor in the energy market and to apply the logistic replacement method, which has proved useful in energy forecasting. Time-constant parameters give a bleak view for geothermal, but if time-variant parameters are justified, the outlook is more encouraging.

INTRODUCTION

There exists great potential for the use of low-temperature geothermal resources for direct heat applications in the U.S. NMEI has a database of sites and can forecast, using the BTHERM model, the locations where such application is feasible; and how geothermal would compare to the locally competitive conventional fuels. By aggregating the results nationally, an upper limit may be obtained on the possible utilization of direct heat from geothermal energy, using the best current information. The fraction of that upper limit that can actually be expected to be realized over time, depends primarily on the size of the economic advantage to the consumer. The problem is to account for the consuming market's resistance to change.

METHOD

As a new technology penetrates a market controlled by one or more older ones, a consistent pattern of adoption seems to be followed, whether the market is for locomotives or rubber or butter. A few consumers will adopt a change immediately, most will wait to guage its success, and some will continue to resist it even after its acceptance is widespread. Although many different techniques may be used to try to quantify this behavior, one very successful one, and the one used here, is the logistic method. It is attractive for two reasons. The first reason is that only a small number of parameters are necessary, and they are parameters with clear intuitive meanings. The second reason is that it is a model that has some basis in, or correlation with, historical fact.

Strictly speaking, logistical substitution applies to a market shared by only two competitors. Peterka (1) has generalized the problem to that of a market shared by many competitors at once. A detailed treatment of this method may be found in his paper. Marchetti and Nakicenovic (2) have applied his method with success to many different sections of the global energy market.

Considering an entire market shared by a number of competitors, the fraction of the market controlled by each at any time can be estimated according to Peterka's model, requiring only two parameters be known for each. The less critical parameter is the specific investment. It may be thought of as the amount necessary to increase the production capacity of a given competitor by one unit. The specific investment is a measure of the relative difficulty of increasing the market share of that competitor.

The second, more important parameter is the specific cost of producing a unit of that competitor from existing capacity, including materials and labor costs, amortization of capital, taxes, interest on debt, and disposal of wastes; but reduced by the amount of any perceived superiority in quality in the eyes of the consumer. It is a measure of the attractiveness of a competitor to the market, which is the driving force behind an increase in the share held.

The cost is found to be the larger determining factor when examples are run. In fact, changing the specific investment even by a factor of two has little effect on the takeover time. One may conclude from this that a capital-intensive competitor does not really suffer a disadvantage if the specific cost of the product can still be kept low, which may be done by mechanizing to lower production costs, or by ignoring waste disposal costs, or by advertising to increase customer appeal.

The only other information necessary is the rate of growth of the market as a whole. In a market of static size, one competitor's gain must be another's loss, but in a market growing sufficiently rapidly all of the competitors may experience growth, though some are declining in their proportionate shares.

Each of these parameters may be constant or vary as a function of time.

ASSUMPTIONS

In the application of the algorithm to the problem of estimating geothermal energy's future market share, two questions arose: What values to use for the input parameters, and how to define the market to be penetrated.

Four alternatives were considered to comprise the competition for this analysis: natural gas, petroleum distillates, electricity, and geothermal energy. For the relatively uninfluential specific investment, precision is not essential. Matters were simplified by assuming for each alternative a specific investment of $15/MBtu/yr.

The great variability in production cost of geothermal energy from one resource to the next, and the difficulty in transporting it over distances, make it difficult to assign a single price to geothermal as a whole, for comparison with the more uniform conventional fuel prices. This difficulty was overcome by using the BTHERM model maintained by the NMEI to sort the resources into selling price ranges.

Although the cost of direct heat geothermal energy production depends on the costs of other sources, such as the electricity for pumping, these form only a small part of the energy gained by the consumer. Hence conventional energy prices were assumed to grow at an annual rate of two percent relative to geothermal. This is not to say that the price of geothermal will actually remain constant, only that it will not increase as rapidly as the cost of heating by conventional means.

The penetration pattern could then be computed for each sub-market, defined as the energy consumers in an area close to a geothermal resource with a production price in a given range. The total penetration could be found by averaging the year-by-year penetrations in each range, weighted by the fraction of the total heat on line that occurred in that range.

RESULTS

As an example, the geothermal price classes and the percent penetration expected in each class by the year 2000 are shown in Figure 1.

Price, $/MBtu	Percent Penetrated
less than $5	91%
$5 - 6	74%
$6 - 7	43%
$7 - 8	16%
$8 - 9	5%
$9 - 10	1%
more than $10	0%

Figure 1

As one would expect, fairly complete penetration occurs in the lower price ranges, and little or none in the higher ranges.

Graphically, the effect is as shown in Figure 2.

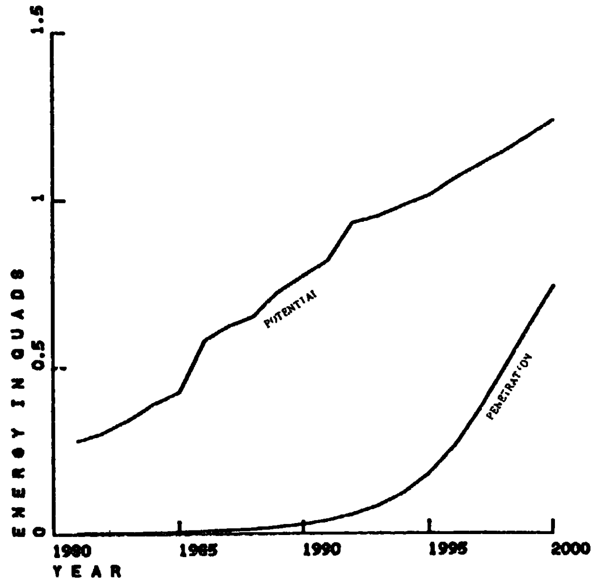

Figure 2

The potential by year comes from Houldsworth (3). Much of the potential lies in the cheaper ranges. Such that 60% penetration is achieved by the year 2000, but with most significant change after 1992. If time-constant parameters had been used, the penetration would have been much smaller - perhaps 10% by 2000, which does seem low.

DISCUSSION

One major popular objection to the use of time-variant parameters is the argument of the so-called "fifty-year time constant." The argument suggests that since past energies seem to have demonstrated a lengthy takeover time in the market, so too must geothermal. The delay is supposedly due, in large part, to the reluctance of owners of "conventional" equipment to abandon their partially amortized systems and adopt new ones. (In this context, "conventional" refers to an older or more established technology which has come into competition from a newer one.)

However, the historical data are perhaps not truly representative of the present case. At no other time was the cost of the "conventional" way of operating escalating so relatively rapidly. One example of this is the past decline of coal when under competition from cheap natural gas. Using historical parameters as constant over time, coal would be expected to continue to decline in the future. But, in fact, as the price of coal becomes more attractive relative to gas and oil, many experts anticipate that coal will begin to increase its share of the energy market again. The conversion from coal to natural gas and oil was different in that it was not forced by rapidly rising coal prices driven by the approaching exhaustion of the coal supply, as now appears to be the case with oil and gas.

For the analysis to date, time-constant parameters may suffice, but the increasing prices of conventional fuels will soon drive them out of the range in which parameter changes can be written off as stochastic fluctuations which will be mathematically smoothed in the long run.

If the year's cost of heating with conventional fuels exceeded the cost of changing to geothermal, people would certainly change, whether the existing system were fully amortized or not. Of course that is an extreme example, but the existance of unamortized conventional equipment is certainly not the sole consideration.

Perhaps the explanation lies in the assumption that an alternative, such as oil, is considered to have the potential of supplying all of the global market. It is not unreasonable to suppose that much of the observed delay in takeover on this scale is simply due to the immense size of the market to be controlled. Direct use geothermal energy cannot come close to supplying so much, but it can supply all of the vastly smaller colocated market that has been assumed here. The gross quantities of geothermal energy dealt with are comparable to amounts of conventional fuels that have indeed come "on-line" historically in equivalent periods of time.

For that reason, the possibility of realizing a significant fraction of the geothermal direct-use potential by the year 2000 is not as remote as it seems.

REFERENCES

Peterka, V., November 1977, Macrodynamics of technological change: Market penetration by new technologies; International Institute for Applied Systems Analysis, Laxenburg, Austria.

Marchetti, C., and Nakicenovic, N., December 1979, The dynamics of energy systems and the logistic substitution model; International Institute for Applied Systems Analysis, Laxenburg, Austria.

Houldsworth, M., November 1980, The potential for direct use geothermal energy supply in the United States, 1980 - 2000; New Mexico Energy Institute, Las Cruces, New Mexico.