CONSIDERATIONS FOR THE PRICING OF GEOTHERMAL ENERGY

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1. Utilities insist that the cost of electricity from geothermal energy be competitive with alternate methods of generating electricity.

2. Most producers consider it appropriate that they receive compensation on the basis of delivered fuel rather than kilowatthours at the busbar. This posture corresponds with the sales practices involving alternate fuels, for example, coal. It also provides an incentive for utilities to operate their geothermal plants efficiently.

However, several problems require attention:

(a) Geothermal power conversion experience is limited and still improving. Accordingly, plant performances might vary substantially from design criteria.

(b) Noncondensible gases may affect a plant's performance adversely and hence limit the value of the resource to the utility.

(c) Producers require assurance that the utility will employ state-of-the-art plant designs that are appropriate to the resource.

The following procedures can be justified for dealing with the above-mentioned problems:

(a) The utility will assure that its design efforts will satisfy such well accepted criteria as:

(1) Thermal efficiency for liquid resources > 232°C (450°F) will be $\geq$ 0.10.

(2) Thermal efficiency for dry steam resources will be $\geq$ 0.15.

(b) The plant hot water rate or steam rate, depending on the resource, will be determined by the first 180 days of operation, during which time the producer will be paid at the busbar on the basis of design hot water rate.

(c) Thereafter, the producer will be paid for the geothermal energy delivered to the plant inlet with the price having been established on a busbar basis during the first 180 days of performance.

(d) In the event that the resource changes properties (e.g., enthalpy, noncondensible gases) necessitating plant revisions resulting in either a reduced or improved plant performance, then the producer and the utility will share in the resultant change in total electricity cost, subsequent to the utility's recapturing investments necessary to such plant revisions.

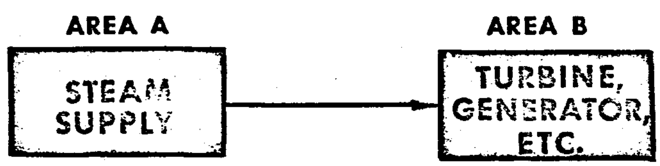
(e) In the event that the utility is able to improve plant performance in the instance of no change in the resource, then the producer and the utility will share the resultant incremental changes in the cost of electricity, providing that the utility may first recapture the investment necessary to such improvements.

(f) In the event that the plant performance declines through no reduction in resource quality, appropriate plant revisions will be absorbed by the utility.

(g) In the event that changes in resource properties adversely affect the plant performance in a manner not resolvable by plant revisions, then the utility will be obliged to revise the price of the resource appropriately.

(h) In the event that the plant operation by the utility necessitates revisions in the producer's production practice, but that the requirement for such revisions is not through fault of the producers, the producer will be appropriately compensated by the utility.

3. The fixed costs for a coal-fired plant plus the price of the coal to fuel it less the geothermal fixed costs equal the equivalent price of geothermal energy, all else remaining equal (load factor, operating costs, etc.) (Figure 1).



$$[COST_A + COST_B] - [COST_B] =$$

GEOTHERMAL PRODUCER PRICE

Figure 1

4. Due to utility-producer accounting differences, the initial price for electricity from geothermal energy might exceed the aforementioned equivalency price, providing that the geothermal price escalates at a lesser rate than that for coal.

5. The producer price involves total service (i.e., steam delivery to the plant inlet), which, of course, incorporates effluent disposal by the producer.

6. Most utilities are not disposed to risk the entire plant investment in the initial plant, in view of the question of reservoir longevity. The producer might consider escrowing a portion of the price for electricity from geothermal energy during the initial years as a means of accommodating that concern.

7. The producer must be concerned about the utilization schedule for a geothermal plant (well throttling is undesirable). Hence, a reward for increased utilization is contemplated.

8. The foregoing considerations are reflected in the following formula for pricing geothermal energy:

$P_g = K_o + B_o$ when L = 80% where:

P_g = geothermal steam price based on coal equivalency

K_o = the fixed costs for a coal-fired plant (Fc) less the fixed costs for the geothermal plant (Fg) in mills/kWh (common time base)

B_o = the true cost for coal plus average coal-fired operating costs minus the average geothermal power plant operating costs.

L = load factor

For load factors other than 80% the formula becomes:

$$P_g - h(K_o + B_o)$$

where:

$$h = \frac{0.8}{0.6} = 1.33 \text{ for } L \leq 0.6$$

$$= \frac{0.8}{L} \qquad \text{for } L > 0.6$$

This system provides incentive for the utility to maintain a high load factor (Figure 2).

Inflation is a real concern in any long-term contract. Figure 3 shows how inflation would affect the price of geothermal energy (P_g) over time.

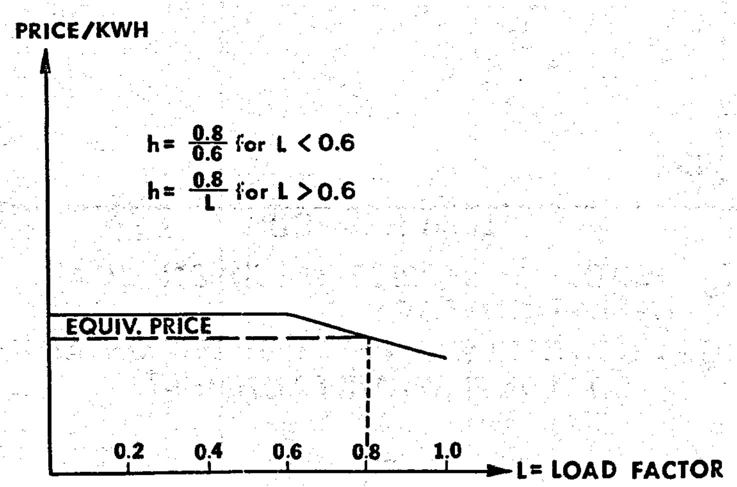
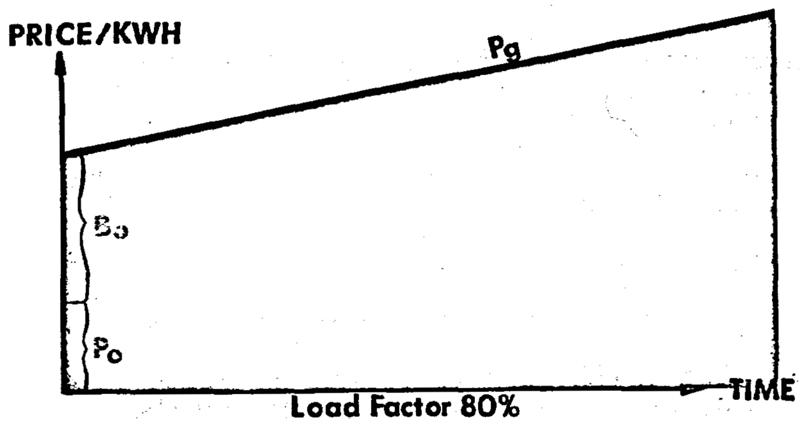


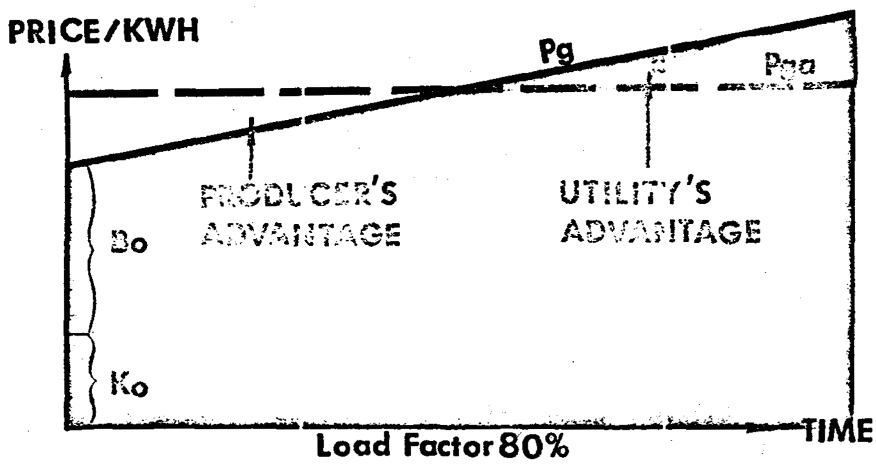
Figure 2



P_g-GEOTHERMAL PRICE BASED ON COAL INFLATION FACTOR

Figure 3

Due to the producer-utility accounting differences (the producer needs early income for a high rate of return, while the utility is concerned with total cost to its customers), both entities might be in a better position if the initial price for geothermal exceeded the equivalency price with the geothermal prices (P_{ga}) escalating at a lesser rate than that for coal. Figure 4 shows the advantage to both the producer and the utility.



P_g-GEOTHERMAL PRICE BASED ON COAL INFLATION FACTOR

Pga - GEOTHERMAL PRICE BASED ON ADJUSTED COAL INFLATION FACTOR

Figure 4

The following equation, provided only for your edification, is one representation of the line P_{ga}:

$$P_{ga} = h\{ K_o + nB_o \ [(E_{t-1}1)\ (2-n)\ +1]\}$$

where:

P_{ga} = geothermal price based on decreased coal inflation

n = a factor to be negotiated $1 < n < 2$

$$E_{t1} = \frac{C_{t-1}}{C_o}$$

where: C_o = the average true cost of coal plus the average coal-fired operating costs

C_{t-1} = average coal cost plus operating cost in the previous time period, probably quarter

Reservoir risk, which seems to be the paramount utility concern, is not covered by the equations or graphs. The producer can share the utilities' reservoir risk through the following escrowing arrangement:

> X percent of P_{ga} will go to the producer while Y percent of P_{ga} will go to an escrow account for time 0 to time M. The escrow account will be capturable by the producer if the reservoir is satisfactory at time M. Otherwise, it will be capturable by the utility, serving as partial compensation.

The increased utility security provided by this arrangement depends on the values of Y and M. The real utility security is that the producers are not going to risk investments in wells and piping until they are satisfied with the reservoir parameter.