# HYDROTHERMAL COST OF POWER

An important factor in the rate of development of hydrothermal energy for electric power production will be its cost relative to possible alternatives including coal and nuclear. Although numerous forecasts of costs have been made, and will be subsequently discussed, the basic economic data necessary to give credibility to these forecasts is lacking. DOE expects to develop accurate cost and performance information for hydrothermal power through two 50 MWe demonstration plants which have been contracted for under cost-shared industry agreements. These plants will provide detailed capital and operating cost data in addition to serving as institutional path finders and technology demonstrations.

The first of these two plants, a flash steam design, will be constructed and operated by the Public Service Co. of New Mexico (PNM) on a high temperature (550°F) resource at the Baca location in the Valles Caldera in New Mexico. This plant is scheduled for start up in 1982. The second demonstration plant, employing an organic binary cycle design, will be constructed and operated by San Diego Gas and Electric Co. (SDG&E) on a moderate temperature (365°F) resource at Heber in the Imperial Valley of California. The binary plant is scheduled for start up in 1984. Cost of power estimates for these plants as well as western coal and nuclear plants are presented in Table I.

Table I

Estimated Busbar Cost of Power (Mills/kwh)*

| Start Up | Geothermal | Initial Year of Operation | Levelized Current Dollars | Levelized Constant Dollars |
|---|---|---|---|---|
| 1982 | PNM Baca Flash Demo (50% DOE funded plant) | 42 | 62 | 36 |
| 1982 | Baca Subsequent unit (no DOE funds) | 43 | 64 | 36 |
| 1985 | SDG&E Heber Binary Demo (cost estimates ignore 50% DOE funding) | 89 | 129 | 75 |
| | **Coal** | | | |
| 1982 | PNM estimate (San Juan unit 4) | 42 | 62 | 36 |
| 1985 | SDG&E estimate (Blythe) | 43 | 64 | 36 |
| 1990 | NRC (report NUREG 0480) | 35 | 58 | 44 |
| | **Nuclear** | | | |
| 1985 | SDG&E estimate (Sundesert) | ** | 50 | 29 |
| 1990 | NRC | 46 | 61 | 37 |

*in year of start-up dollars

** not available

assumptions:

PNM - 80% capacity factor
escalation 7% to 1982

SDG&E - 75% capacity factor
escalation 7% per year to 1985

NRC- 65% capacity factor
5% escalation to 1990
(both coal and nuclear)

This table illustrates the confusion which characterizes comparisons of the cost of power. The calculated (or estimated) generation costs vary with time, capital costs, O&M costs, fuel costs, discount rate, escalation rate and plant capacity factor. Results are presented in three different conventions as noted in the table; first year generation costs, levelized costs in current dollars and levelized costs in constant dollars. The different assumptions cited at the bottom of Table I will account for nominal differences in costs but do not obscure the basic conclusions discussed later.

Levelized costs are constant kwh charges over the life of the plant, which result in a present value of revenues precisely equal to the present value of costs. Levelized costs can be calculated in current (as spent) dollars, resulting in a hypothetical cash flow decreasing in real buying power year after year (analogous to a constant home mortgage payment), or levelized costs can be calculated in constant dollars, which would reflect a revenue stream starting at a much lower value and having constant real buying year after year, but increasing in current dollars each year. Neither method would represent actual year by year kwh charges but both methods would generate the same present value and thus either method can be used to determine the <u>relative</u> attractiveness of alternative investments. Initial year costs reflect the kwh charges in that year's dollars which would actually occur in the year of start up to balance revenues with costs. The initial year costs do not represent a proper basis for determining the relative attractiveness of alternatives, as the out-year escalation rates (for fuel for example) may cause a system with low initial costs to have a higher present value than another system with high initial costs but which is essentially fuel inflation free.

Table 1 shows that hydrothermal energy is cost competitive with coal and nuclear for high temperature resources (as at Baca), but is measurably more expensive at moderate temperature (as at Heber). PNM estimates that a 30 year hydrothermal plant will produce power at essentially the same cost as a 40 year coal plant. PNM assumes the second plant at the Valles Caldera site will have lower O&M and fuel costs which essentially compensate for the DOE 50% subsidy of the demonstration unit. SDG&E shows their moderate temperature generation cost estimates to be twice as high for geothermal as coal and 2 1/2 times as high as nuclear. SDG&E projects lower costs for subsequent hydrothermal units but has not attempted to quantify these projections.

The reasons for high costs on the proposed SDG&E binary plant are straightforward. At $365^{\circ}F$, the binary plant requires approximately 2 1/2 times the brine flow rate as the $550^{\circ}F$ flash plant. This higher brine flow dictates larger piping, valves and reinjection pumps. The lower temperature necessarily means a 20 percent lower thermal efficiency, which requires approximatly 20 percent larger condensers, cooling towers, water circulating pumps and 20 percent more makeup water. In addition, the lower vapor pressure of the $365^{\circ}F$ brine causes wells to be low in productivity unless they are pumped. The binary plant will use approximately 5MW of parasitic power for downhole pumps which is not required for the $550^{\circ}F$ resource, plus an additional 2MW of parasitic power for injection pumps. Capital costs for downhole pumps add 2 1/2 million dollars in initial cost and will require frequent maintainance and replacement. It is clear as Table 1 indicates,, that moderate temperature resource utilization with current technology is not competitive with coal and nuclear.

The dominant cost in hydrothermal energy is that of fuel (hot water and steam) which accounts for 50-75% of the kwh charges. Although hydrothermal energy may be more costly from moderate temperature resources, market penetration might still proceed under certain circumstances because this resource is relatively benign environmentally, and coal and nuclear may be discouraged by state policy (as in California).

High hydrothermal fuel costs can be attributed primarily to high drilling costs, low reservoir temperature (requiring more wells) or low well productivity. The prospect for improving economics through technological progress is excellent, especially for the moderate temperature resources (which constitute 80% of the inferred 140,000 MW recoverable resource). Drilling technology development, reservoir stimulation for the purpose of increasing well flow, downhole pumps and more efficient conversion systems have a realistic potential for cutting moderate temperature costs in half, which is why the development of geothermal technology is an important part of the Federal geothermal program.

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