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THE UTILIZATION OF HOT DRY ROCK
- A Scenario -

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ABSTRACT

A scenario is a statement of what could possibly happen, based upon a knowledge of what currently exists and upon what may be reasonable assumed. A scenario is not a prediction of what is likely to occur.

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The year 1990 was realized to have been the harbinger of scarce traditional energy supplies. Twenty years earlier, energy economists and visionary scientists had forecast that the 1990's into the year 2000 would be severe in terms of oil and gas shortages. True, coal had made an impact on the energy scene, and its use had helped to alleviate some of the unpleasant times over the past years, such as the OPEC oil embargoes of 1979 and 1986, and the closing of the Alaskan pipeline in 1893 due to a major structural flaw. However, coal burning brought its own problems, especially in air pollution. A greater than ever amount of sulphur, sulphuric acid and particulates hovered over many cities. Because of the relatively large coal reserve, many industries and utility companies switched over entirely to coal; yet these industries were now facing strict new federal legislation limiting coal burning in dangerous highly polluted areas. It came as a surprise to no one that citizens were desperately urging their congressmen to pass immediate "crash" programs to develop alternate energy sources such as solar, wind, and geothermal. If government had been responsive to industry by providing, for example, geothermal exploration with the same intangible drilling expense tax break allotted to the oil industry, much of the needed exploration incentive would have spurred development and production at an earlier time.

The city of Saddle Creek in the Rocky Mountains with a population of 22,000 and about 6,000 houses initiated a plan in 1977 that would make them energy independent by the turn of the century. The motivation for the action was precipitated from the oil embargo of 1974 which left Saddle Creek with a three weeks' supply of fuel oil and a bankrupt oil distributor. Located within a potential KGRA (Known Geothermal Resource Area) the citizens of Saddle Creek voted for a bond that would help finance preliminary geological/geophysical exploration of their energy potential.

A local geothermal exploration company was hired for the initial exploration work that was structured to meet the following criteria:

1. To determine if the geothermal resource (if any) was adequate to support converting the buildings of Saddle Creek for long-term utilization of geothermal fluids for space heating purposes.

2. To determine the costs and practicality of remodeling the existing heating systems using low temperature (80°C) water.

3. To prepare a design model of the geothermal distribution system that would be adequate for the intended purpose.

4. To examine environmental questions.

5. To build and test the proposed geothermal system to accurately demonstrate construction and operation costs. (Schmitt et al, 1976).

A brief breakdown of the results of the geothermal consulting firm was the following:

A. Geological Studies

1. Remote sensing of the area helped in locating faults and in the mapping of surface features around Saddle Creek.

2. Hand samples of rock enabled a detailed petrographic study of the area so that a prediction of the rock type at depth could be made.

3. A detailed study was made to determine the fracture orientations of the rock because the analyzed basement rock is believed to be crystalline and impermeable, therefore perhaps necessitating future fracturing for water circulation.

B. Geophysical

1. Heat flow studies - These revealed the existence of a large regional conductive heat flow, and it was suspected that this was associated with an active magma chamber.

2. Seismic refraction and magnetometer surveys - These determined that the basement rock was within two kilometers of the surface and that minor indications of active fault zones or dormant faults existed in the target area.

3. Geoelectromagnetic studies - These were helpful in locating and determining subsurface heat flows and useful resistivity parameters.

C. Exploratory Drilling

1. Four wells were drilled to measure temperature gradients with depth, as well as a sampling well, which would have been used had any fluid been present to sample.

2. The exploratory wells revealed that a high temperature of 160°C was found at the bottom of an 8,000 foot well.

These limited geological and geophysical investigations of the Saddle Creek area pointed to the evidence of a geothermal resource, and especially a hot dry rock resource, these criteria being:

1. An attractive temperature at an economic drilling depth,

2. Impermeable basement rock,

3. A lack of active faults, (Laughlin and West, 1976).

Economic factors are also essential in the development of any enterprise and the City of Saddle Creek decided that it should commission a study of a proposed geothermal system amortized over a reasonable length of time (20-30 years) vs. the present cost of fuel oil escalated through the same period of time. Figure 1 presents graphically the results of this study.

Motivated by the long term value of geothermal exploration and space-heating production, the important consideration of degree days was investigated. Saddle Creek has less than 6000°F degree days per year. If the proposed system was exclusively geothermal, (based on a usable temperature of 120°F) then the system would have to be efficient in the winter low range of -12°F. However, in this range, the system would operate at 20%-22% efficiency, and it would be difficult to justify such a cost intensive project for such a relatively low utilization factor. The consideration was then proposed to design the geothermal system in the 20°F-30°F range in order to maximize utilization during most of the heating season months. If temperatures over a given month dropped below the efficiency of the geothermal system, a backup fossil fuel system would then become operable. The graphs in Figure 2 help to justify this rational.

Comments that are applicable to the graph are the following:

1. Designing the system for twice the load is made by halving the normal temperature design.

2. With fossil fuel peaking for colder days, fossil fuels need to supply only 6% of the total energy requirements.

3. Overall economics of geothermal heating is improved by about 35%. (Kunze et al; 1977).

With geologic and economic analysis showing favorable signs for hot dry rock geothermal development, an adequate source of water was needed. The nearby Menick River with its near drinking quality water was chosen as a source. As the proposed system would be an elongated circulation loop, a volume of water equal to the carrying capacity of the pipe network as well as the cross-sectional area of circulation loop within the fractured reservoir would be needed. A reservoir was built for this purpose by damming the river with an added volume of water to serve as a built-in reserve to compensate for water loss due to subsurface loss and surface evaporation.

Other necessary factors were considered and the town decided on the following plan of action.

1. A legal advisor was hired to interpret and recommend State and Federal laws that would guide the resource development.

2. An application to the Department of Energy was made for an approved guaranteed loan where up to 75% of the costs toward geothermal energy development up to a value of fifty million dollars would be covered.

3. The solicitation of advice in the exploration and development of the hot dry rock resource was sought from the national scientific laboratories.

4. The establishment of a watchdog committee to oversee any potential insurmountable environmental problems such as micro-earthquakes caused by hydrofracturing, subsidence, air pollution, or ground water pollution.

Eventually, Saddle Creek subcontracted many aspects of development and production to qualified firms, and the city was using geothermal energy to meet all of its heating needs at a substantial reduction over traditional fuel costs by 1990.

References:

Schmitt, R. C., Donovan, L. E., Spencer, S. G., Keller, J. G., and Stoker, R. C., 1976, Report to the Idaho Governor-Project Summary for the Boise Space Heating Project: Idaho National Engineering Laboratory.

Laughlin, A. W., and West, F. G., 1976, The Zuni Mountains, New Mexico, as a Potential Dry Hot Rock Geothermal Energy Site: Los Alamos Scientific Laboratory, LA-6197-MS.

Kunze, J. G., Donovan, L. E., and Griffith, J. L., 1977, The Size Effect for Distant Space Heating in Boise, Idaho: In Geothermal: State of the Art, Transactions, Geothermal Resources Council, Vol. 1, 1977.

Rowley, J., LASL, Personal Communication, 1978.

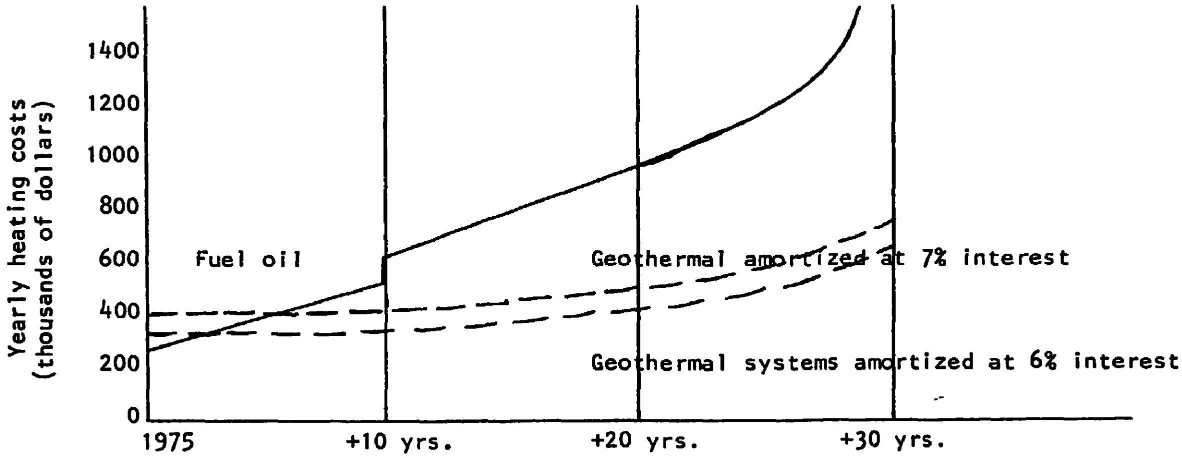
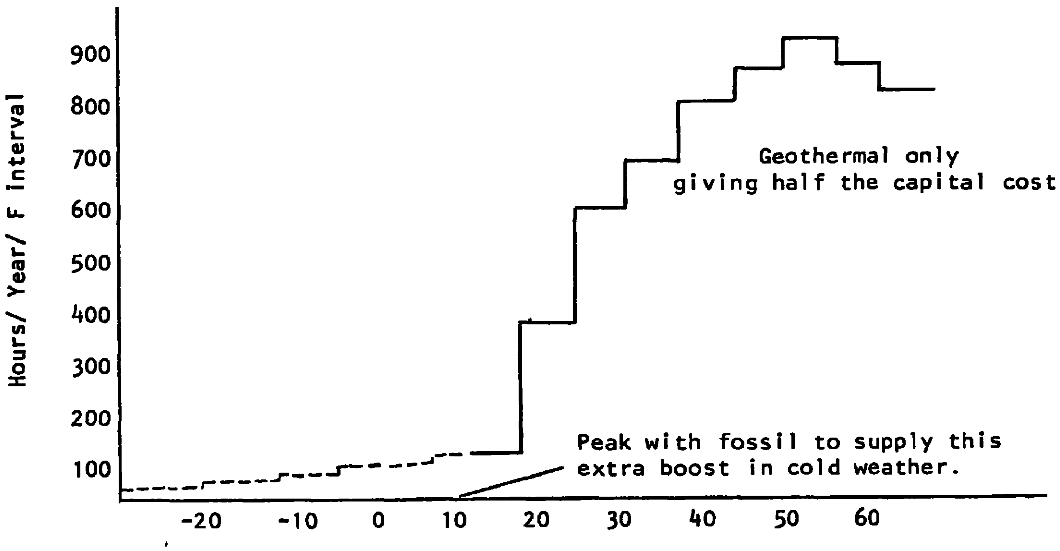


FIGURE 1

(Adapted)
(Schmitt, et al, 1976)



(After Kunze, Donovan & Griffith - 1977)

FIGURE 2