Geothermal Resources Council, TRANSACTIONS Vol. 6, October 1982

GEOTHERMAL RESOURCE, ENGINEERING AND ECONOMIC EVALUATION FOR THE CITY OF OURAY, COLORADO

Richard T. Meyer
Harold Prostka
Rob Raskin
John R. Zocholl

Western Energy Planners, Ltd.
11100 East Mississippi Avenue, Suite 1-102
Aurora, Colorado 80012

ABSTRACT

A geothermal energy feasibility study has been performed for the City of Ouray, Colorado, to determine the potential economic development opportunities to the City. The resource assessment indicates the resource to be associated with the Ouray fault zone, the Leadville limestone formation, the high thermal gradient in the area of the San Juan mountains, and the recharge from precipitation in the adjacent mountains. Four engineering designs of alternative sizes, costs, applications, and years of start-up have been defined to offer the City a range of development scales. Life cycle cost analyses have been conducted for cases of both public and private ownership. All systems are found to be feasible on both economic and technical grounds.

INTRODUCTION

The City of Ouray, Colorado, with partial financing from a DOE Appropriate Energy Technology Small Grant Award, has sponsored a geothermal resource, engineering and economic feasibility study. The purpose of the study project has been "to explore new ways for the City to use its geothermal energy for economic development and diversification." The project objectives have been (1) to create new tourism and commercial business opportunities, (2) to generate additional revenues for the City and its businesses, (3) to reduce energy costs for city and county buildings, for commercial businesses, and for residences, (4) to achieve year-round optimum use of geothermal energy, and (5) to preserve the rights and uses of geothermal springs and waters by parties already engaged in or entitled to use of geothermal energy.

RESOURCE ASSESSMENT

Geologic Setting: Ouray is located in a region of high heat flow, perhaps four times that of the world average (Zacharakis, 1981). Active faulting and a moderate to high level of seismic activity also characterize the region. Faults less than 2 million years old on the Uncompahgre Plateau are only 22 miles northwest of and on strike with Ouray (Howard and others, 1978). A seismic study of the Ridgway fault zone 12 miles north of Ouray shows it to be seismically active (Sullivan and Martin, 1981). Ouray lies at the intersection of several major faults. The Ouray fault that is associated with the hot springs at Box Canyon is one of several faults of WNW to ENE trend that make up the complex, 3-mile wide Ouray Fault Zone (O.F.Z.) that is the boundary between the Ouray Graben and Sneffels Horst.

The Ouray Geothermal System: The thermal springs at Ouray are probably the result of deep circulation of meteoric water in fractures and permeable sedimentary rocks of the Ouray Graben. The graben contains a maximum of 8800 feet of sedimentary rocks; about 3300 feet are aquifer zones. Within the graben, groundwater flow is probably largely confined to the two main aquifer zones. But in the basin margin fault zones, fracture permeability permits downward recharge of the aquifers and upward flow of deep thermal waters, as at Ouray and Ridgway. Recharge is mostly from the San Juan Mountains along the south flank of the graben, through steep intersecting fractures of the Ouray and other fault zones. The geothermal gradient is sufficiently high to heat the deeply circulating groundwater. The flow path, from recharge to discharge area, is much shorter for the Ouray thermal water than for the water of the Ridgway area. The resulting difference in subsurface residence time of the waters of the two areas is reflected in consistent differences of water chemistry and temperature. Orvis thermal water is more mineralized (2300 vs. 1650 ppm TDS) and has a higher geochemical reservoir temperature (78°C vs. 70°C) than Ouray thermal water (Barrett and Pearl, 1976, 1978).

Temperature within the graben can be estimated from the depth of fill and the geothermal gradient. The total sedimentary-volcanic section above PE basement is a maximum of 8800 feet thick. The geothermal gradient is 40°C/km, which amounts to a temperature difference of 117°C between the top and bottom of the section. Adding the average annual surface temperature of 7°C (Benci and McKee, 1977) gives 124°C as the maximum expectable temperature at the bottom of the graben. The "average" temperature within the graben would be about half that or 66°C, which checks closely with the 69°C temperature of the Box Canyon Pool Spring at Ouray. The chalcedony-silica geothermometer yields a subsurface temperature of only 69°C to 71°C (Barrett and Pearl, 1978). This is very close to the surface temperature of Pool Spring and may mean that the thermal waters are ascending rapidly with little cooling or high-level dilution.

The rate of recharge can be estimated from the average annual precipitation, which is about 40 inches per year (U.S. Weather Bureau Map). This computes to 93 million cubic feet of water per year per square mile, or 177 cubic feet per minute per square mile. Since 1 cubic foot = 7.48 gallons, the precipitation rate is 1323.5 gallons per minute per square mile. Only part of this water actually recharges the Ouray geothermal system. We assume that only one-eighth of the recharge, or about 3300 gallons per minute of hot water, is ascending beneath Ouray. The measured natural discharge from the thermal springs at Ouray ranges from 60 to 200 gpm. The greater part of the geothermal resource is apparently leaking out of the system elsewhere. A considerable amount of hot water may be lost up bedrock fractures into shallow surficial deposits, becoming diluted with cold groundwater.

It isn't possible to predict what effect drilling and pumping would have on the natural springs at Ouray. The permeability of the LL and fracture zones is unknown, hence the potential productivity of the system cannot be calculated. However, because the recharge rate is high, and the temperature and chemistry of the waters seem to indicate rapid ascent, the indications are favorable that the system may have the capacity to sustain a ten-fold increase in discharge without adversely affecting the existing springs.

ENGINEERING DESIGNS

Four engineering designs have been evolved to provide a range of development and/or application options for the City of Ouray. The City may choose to initiate geothermal development with the smallest scale option and proceed sequentially to enlarged geothermal systems until a complete city-wide district heating system is achieved. Or the City may choose to start out with an intermediate size system and progress from that design. However, the City may also choose to proceed with design and construction of a full-scale city-wide geothermal system. The four engineering designs presented herein give the City the opportunity to examine at this time the engineering design factors, the capital costs, and the construction aspects of four alternative size systems. The four engineering designs are briefly described here.

Case A: Space and Hot Water Heating of Public Buildings: The existing pipeline and geothermal waters from the Box Canyon Pool Spring to the Municipal Pool would be the source of hot water; no geothermal wells would be drilled. The existing pipeline would be tapped into at the base of Sixth Avenue and a portion of the Pool Spring water would be pumped up to the public buildings through a newly-installed insulated pipeline. The new pipeline system would serve the City Hall, the County Courthouse, the Museum, the School Gymnasium, and the proposed Emergency Services Building. The discharge water would be returned through a parallel insulated pipeline to the Pool Spring Pipeline at the base of Sixth Avenue and added to the flow to the Municipal Pool. The water in the existing pipeline is estimated to be 155°F and flow at 200 gpm. Under the peak demand situation, 124 gpm at 155°F would be required to provide thermal energy to the five buildings. This 155°F geothermal water would be lowered in temperature to 120°F and returned to the pool pipeline at 115°F. The resultant water flowing to the pool would be 130.2°F at 200 gpm, which represents the "worst case" condition.

Case B: Same as Case A, Except with the Addition of Space and Hot Water Heating for the Municipal Bathhouse and a Prospective Year-Round Recreation Center: Case B is basically the same as Case A, except that it provides for year-round use of the Municipal Pool, which requires space heating and hot water for the existing Bathhouse; it also allocates water from the Box Canyon Pool Spring pipeline to provide space and hot water heating for a prospective new year-round Recreation Center, which would be located in the immediate vicinity of the Municipal Pool and Bathhouse. Capital costs for Case B include retrofit costs for the Bathhouse but not building or heating system costs for the Recreation Center; only the energy load of the Recreation Center is incorporated into the design.

Case C: Main Street Commercial Strip, Including Public Buildings, Municipal Bathhouse and Recreation Center: Case C is designed to be a completely new geothermal system of geothermal wells and pipeline system. The design provides for two geothermal wells to be drilled at the northern edge of the City, to a well depth of 800 to 900 feet into the Leadville Limestone Formation. The two wells would be connected to a pipeline system which comes up Main Street and which has side-street branches in order to service most of the existing commercial businesses and motels. The Main Street pipeline would also connect with a major branch line to service the public buildings which are defined in Case A. Estimating the geothermal resource to provide 175°F and 400 gpm per well, two wells would be required to meet the thermal needs for the above locations. The total capital costs for Case C, including retrofit of the five buildings in Case A and all engineering design and contingencies, is estimated to be $720,000 in 1982 dollars.

Case D: Year 2000 City-Wide District Heating System: Case D is an engineering design incorporating six geothermal wells at the north end of town and a pipeline array which would supply most of the residences, commercial establishments, and light industry in the immediate area of the City in the Year 2000. The Year 2000 energy demand estimate is approximately 200 billion BTU per year. Peak commercial and residential demands are estimated equally at 30 million BTUH each. Estimating the geothermal resource to be available at 175°F and 400 gpm per well, six wells would be required to meet the city's thermal energy requirements.

The total estimated cost to develop the wells, for the well, circulating and booster pumps, including engineering design costs and contingencies, in 1982 dollars is $875,000. The total estimated cost for the well collection system and the transmission line, including engineering design, installation, and contingencies, is estimated to be $1,875,000 in 1982 dollars. The total capital costs for Case D is then computed to total $2,750,000.

ECONOMIC EVALUATIONS

Summary of Costs: Table 1 summarizes the estimated exploration, capital equipment, working capital, and annual operating and maintenance costs for the four engineering designs. Also listed in Table 1 are the total BTU equivalents of fossil fuel to be displaced by the geothermal systems, the total investment cost per MMBTU displaced, and the annual O&M cost per MMBTU displaced. The latter two sets of numbers suggest that significant economies of scale can be achieved with the larger geothermal systems.

Results of Evaluations: Table 2 summarizes the results. In each privately-financed case, the desired rate-of-return is specified and the first-year MMBTU-price to the Ouray consumer is calculated. For the publicly-financed case, the break-even price, which meets all operating, maintenance, and bond indebtedness costs, is determined. For comparison, Table 3 presents the expected costs of fuels currently in use in Ouray. It is seen that under all options, geothermal energy is highly competitive with propane and fuel oil. The highest first year geothermal price is Case A - Private at $5.39/MMBTU in 1983. Propane fuel oil prices are expected to be $10.10/MMBTU in that year. The previously projected effect of the economy of scale for Case D is confirmed here. At $2.70/MMBTU in 1986, Case D is also competitive with coal, which is projected to cost $3.63/MMBTU in that year. Year by year cash flows for the five options are available and have been provided to the City of Ouray.

Table 1

Cost Summary (1982 Dollars)

Cost Element	Case A	Case B	Case C	Case D
EXPLORATION COSTS	-	-	$30,000	$50,000
CAPITAL COSTS				
Well and/or Pump Costs	$10,000	$10,000	$279,700	$875,000
(No. of Wells)	(0)	(0)	(2)	(6)
Transmission Line Costs	$80,400	$80,400	$287,500	$1,875,000
Building Retrofit Costs	$21,800	$32,800	$32,800	-
Total Capital Costs	$112,200	$123,200	$600,000	$2,750,000
WORKING CAPITAL	$16,800	$18,500	$90,000	$412,500
TOTAL INVESTMENT	$129,000	$141,700	$720,000	$3,212,500
ANNUAL O&M COSTS	$11,900	$12,200	$28,600	$121,000
MMBTU DISPLACED	4,900	6,600	31,000	233,000
TOTAL INVESTMENT PER MMBTU DISPLACED	$26	$21	$23	$14
ANNUAL O&M COST PER MMBTU DISPLACED	$2.42	$1.85	$0.92	$0.52

Table 2

Economic Evaluation Results Summary

Parameter	Case A (Public)	Case A (Privately owned & operated franchise)	Case B	Case C	Case D
1st Year of Operation	1983	1983	1983	1985	1986
1st Year $/MMBTU	$3.50	$5.39	$4.22	$4.10	$2.70
DCFROR	---	15%	15%	20%	20%

Table 3

Projected Conventional Fuel Prices (Dollars per MMBTU)

	Propane and Fuel Oil	Coal
1982	$ 9.10	$2.50
1983	10.10	2.75
1984	11.21	3.02
1985	12.45	3.33
1986	13.81	3.63

REFERENCES

Barrett, J. K. and Pearl, R. H., 1976, Hydrogeological data of thermal springs and wells in Colorado: Colorado Geological Survey Information Series 6, p. 124.

Barrett, J. K. and Pearl, R. H. 1978, An appraisal of Colorado's geothermal resources: Colorado Geological Survey Bulletin 39, p. 229.

Benci, J. F. and McKee, T. B., 1977, Colorado monthly temperature and precipitation summary: Colorado.

Climatology Office, Climatology Report No. 77-1, Colorado State University.

Howard, K. A., and others, 1978, Preliminary map of young faults in the United States as a guide to possible fault activity: U.S. Geological Survey Map MF-916.

Sullivan, J. T. and Martin, R. A., 1981, Seismic hazard studies for Ridgway damsite, Colorado: Colorado tectonics, seismicity, and earthquake hazards: Colorado Geological Survey Special Publication 19, p. 30-31.

Zacharkis, T. G., 1981, Revised heat flow map of Colorado: Colorado Geological Survey Map Series 18, scale 1:1,000,000, DOE/ET/28365-12.