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Geothermal Resources Council, TRANSACTIONS Vol 5, October 1981

AN ECONOMIC APPRAISAL OF THE USE OF GEOTHERMAL ENERGY IN STATE-OWNED BUILDINGS IN COLORADO

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ABSTRACT

An appraisal of the use of geothermal energy for space heating requirements for selected state-owned buildings in six communities in Colorado was performed for the Colorado Geological Survey. The complete appraisal addressed several components of a feasibility study for geothermal applications, including resource assessment, pipeline rights-of-way, well design and drilling program, conceptual engineering designs for retrofits of building heating systems, evaluations of economic feasibility, institutional requirements, and environmental considerations. Economic feasibility was determined from evaluation of four economic measures: simple payback period in years; twenty-year annualized system costs (geothermal system versus conventional system); total twenty-year undiscounted "energy" savings; and total twenty-year present value "energy" savings. The results showed that several of the state facilities are likely candidates for conversion to geothermal hot water systems. The best candidate is the Colorado State Reformatory at Buena Vista.

INTRODUCTION

The Colorado Geological Survey has been conducting assessments of the geothermal resources of the State for several years. In addition, a major geothermal commercialization planning program has been underway since 1977. Results of these projects are documented in numerous publications by the Survey. In 1980, the State Legislature appropriated funds for an appraisal of the use of geothermal energy in state-owned buildings. This report represents the product of that appraisal, which was conducted during the fall and winter of 1980.

Eleven state-owned buildings in six Colorado communities were selected by the Colorado Geological Survey for the appraisal. The selection of locations and facilities was based upon proximity to documented geothermal resource areas within the state. The locations and buildings are:

- Alamosa - Adams State College and State Highway Department Buildings
- Burlington - State Highway Department Building
- Durango - Fish Hatchery, Ft. Lewis College, National Guard Building and State Highway Department Building
- Glenwood Springs - State Highway Department Buildings
- Steamboat Springs - State Highway Department Building

ECONOMIC EVALUATIONS

The purpose of the economic evaluations of the prospective geothermal space heating systems for the state-owned buildings is to determine which geothermal systems are economically competitive with the existing conventional fuel systems according to specified decision criteria. Generally speaking, new heating systems can only be competitive with existing systems when the sum of initial capital costs and the associated annual energy, operating and maintenance expenses, aggregated over a period of years, are less than the aggregated fuel, operating and maintenance costs for the existing system over the same period of years. Existing systems have the outright advantages that the initial capital costs for those systems have already been expended in the earlier construction of the facility and/or are being amortized in the price of fuel delivered to the facility by the fuel supplier. Therefore, from a purely economic point of view, new systems must achieve savings in actual energy costs over some future period of time in order to be competitive.

Factors other than just economic competition can exist for some facilities or circumstances, however, which can influence a decision to install a new heating system. One example occurs if the existing system is old, wearing out, and in need of substantial repair. A second example occurs if the availability of the conventional fuel becomes limited or highly interruptible. Another example occurs when a governmental entity declares that a given type of fuel can no longer be used as a heating fuel by certain classes of facilities. In these situations and others, economics may no longer be important.

For the purpose of this appraisal of geothermal systems for state-owned buildings, four different economic measures have been calculated. The four measures are (1) simple payback period in years, (2) twenty-year annualized costs, (3) total

20-year "energy" savings without discounting the future value of money, and (4) the present value of the 20-year "energy" savings with a 10 percent per annum discount factor applied.

ECONOMIC AND FINANCIAL ASSUMPTIONS

Certain economic and financial assumptions are made in the calculations of the four economic measures because the future cannot be projected with absolute accuracy. Specific values have to be assumed for the escalation rates of fuel and electricity prices, escalation rates of labor and maintenance expenses, costs of capital for construction and investment, and interest and bond rates. For the purpose of this appraisal, the assumed baseline set of economic and financial factors are: cost of capital for construction - 8%; annual escalation rates for labor and maintenance - 10%, for natural gas, propane and fuel oil - 9%, for electricity - 9%; state investment rate - 10%; and general inflation rate - 8%. Values other than those assumed for the baseline set of economic and financial factors are equally valid, since it is difficult to project the future in today's energy and economic environment.

GEOTHERMAL CAPITAL IMPROVEMENT COSTS

The geothermal capital improvement costs for each state-owned building are compiled from the resource assessment data, the production well engineering program, the building retrofit engineering designs, and the fluid disposal procedures. The data are provided in detail in the project report to the Colorado Geological Survey, but are summarized here in Table 1. The total capital costs span a large range, from $23,597 for the Highway Department Building in Burlington to $16,721,437 for Ft. Lewis College in Durango. Most of the water-to-air heat pump systems for the smaller Highway Department Buildings fall in the cost range of $23,000 to $40,000; next is the heat exchanger/deep well system for the Highway Department Buildings at Glenwood Springs at $114,356; then the Fish Hatchery at Durango at $721,138 and the Highway Department Buildings at Alamosa at $722,880. The larger facilities, the two colleges and the reformatory with their several geothermal options, all run several million dollars each. The geothermal system costs for the Fish Hatchery, Highway Department Building, and Ft. Lewis College in Durango are exceptionally high because of the prorated costs from the 15-mile geothermal trunk line from the Tripp/Trimble and Pinkerton resource areas.

SUMMARY OF ECONOMIC EVALUATIONS

Table 2 summarizes the results of the economic evaluations for the geothermal options considered for each state-owned building; they are for an assumed 15 percent per year conventional fuel price escalation, a 20-year life cycle, and a 10 percent discount rate. In all cases except the Colorado State Reformatory, an average accumulated use duration of 4320 hours (approximately 6 months) per year is assumed; domestic hot water requirements during the warm months are assumed to be provided by existing or replacement conventional fuel hot water heaters. The Colorado State Reformatory uses a considerable amount of hot water all year round, so the geothermal system is prescribed to operate continuously.

On the simple payback period measure of 20 years, the geothermal options at the following facilities appear to be economically feasible:

- Adams State College (central heat exchanger or heat pump)
- Colorado State Reformatory (all three resource sites)
- Buena Vista Highway Department Building (heat pump)
- Burlington Highway Department Building (heat pump)
- Durango National Guard Building (heat pump)
- Glenwood Highway Department Building (heat exchanger)
- Steamboat Springs Highway Department Building (heat exchanger and heat pump).

On the 20-year annualized cost measure and on the total 20-year present value savings measure, six facilities (and ten geothermal options) appear economically feasible; the Burlington Highway Department Building is excluded by these measures. The total 20-year undiscounted savings measure, however, finds all of the facilities and geothermal options to be feasible except for the Alamosa Highway Department Buildings and the heat exchanger option for Ft. Lewis College.

CONCLUSIONS

Several of the state-owned buildings appear to be economically feasible for retrofit to geothermal heating systems. The Colorado State Reformatory at Buena Vista is the most economically attractive facility for a geothermal capital improvement because of the year-round consumption of large quantities of hot water, the high price of natural gas, the match between the resource temperature and the required hot water temperature, and the ease of disposal of the discharge water. Adams State College also appears to be economically suited to a geothermal demonstration project, at least for a central heat pumps system and if domestic hot water requirements during the warm months can be provided by auxiliary heaters. The Highway Department Buildings at Glenwood Springs and Steamboat Springs are economically practical applications of geothermal heat exchanger systems under either the simple payback or the total 20-year undiscounted savings measures, if the geothermal well costs are prorated to other users of the excess flow of hot water. The use of heat pumps for the Highway Department Building at Buena Vista and for the National Guard Building at Durango is economically feasible if fuel prices escalate faster than electricity prices. Geothermal systems for the Fish Hatchery, Ft. Lewis College and the new State Highway Department Building in Durango are not economically practical.

REFERENCES

Meyer, R. T., Coe, B. A., and Dick, J. D., 1981, An appraisal for the use of geothermal energy in state-owned buildings in Colorado; Colorado Geological Survey, Resource Series 14, 65 p.

Table 1. Summary of Geothermal Capital Improvement Costs for the State-Owned Buildings

LOCATION/FACILITY	GEOTHERMAL OPTION	PRODUCTION WELL SYSTEM	TRANSMISSION LINE SYSTEM	CENTRAL DISTRIBUTION SYSTEM	BUILDING RETROFIT	REINJECTION OR DISPOSAL	TOTAL CAPITAL COSTS
ALAMOSA							
Adams State College	Heat exchanger, Artesian flow with pumping, on-site	$828,800	$45,738	$281,325	$1,962,325	$556,490	$3,674,678
	Heat pump, Artesian flow with pumping, on-site	$391,900	$15,246	$1,017,445	$387,926	$298,870	$2,111,387
Highway Dept. Building	Heat exchanger, Artesian flow with pumping, on-site	$379,500	$4,235	$44,813	$22,687	$271,645	$722,880
BUENA VISTA							
Colorado State Reformatory	Direct heating, pumped flow from Chalk Creek No 1	$408,600	$3,201,759	$423,016	$350,910	$36,300	$4,420,585
	Direct heating, gravity flow from Chalk Creek No. 2	$581,100	$3,251,095	$423,016	$350,910	$36,300	$4,642,421
	Direct heating, gravity flow from Cottonwood	$402,900	$2,904,319	$423,016	$350,910	$36,300	$4,117,445
Highway Dept Building	Heat pump, shallow well on-site	$11,475	$1,331	-	$20,963	$484	$34,253
BURLINGTON							
Highway Dept Building	Heat pump, shallow well on-site	$6,500	$1,331	-	$14,798	$968	$23,597
DURANGO							
Fish Hatchery	Heat exchanger coupled to trunk line	$70,298	$592,191*	$38,018	$19,663	$968	$721,138
Fort Lewis College	Heat pump coupled to trunk line	$666,000	$5,639,912*	$1,597,890	-	$461,615	$8,365,417
	Heat exchanger coupled to trunk line	$1,329,957	$11,235,200*	$597,220	$2,643,695	$915,365	$16,721,437
Highway Dept Building	Heat exchanger coupled to trunk line	$132,996	$1,127,634*	$17,951	$243,210	$21,296	$1,543,087
National Guard	Heat pump, shallow well on-site	$12,150	$1,331	-	$26,116	$968	$40,565
GLENWOOD							
Highway Dept Building	Heat exchanger, deep well on-site	$26,440	0	$38,306	$23,474	$26,136	$114,356
STEAMBOAT SPRINGS							
Highway Dept. Building	Heat exchanger, deep well on-site	$10,700	$1,331	$5,082	$21,151	$968	$39,232
	Heat pump, shallow well on-site, Artesian flow	$10,775	$1,331	0	$17,600	$968	$30,674

*Includes prorated portion of trunk line

Table 2 Summary of Economic Evaluations for Geothermal Options Compared to Conventional Fuel Systems for State-Owned Buildings (Assumptions 15% Fuel Price Escalation, 10% Discount Factor, 20-Year Life)

LOCATION/FACILITY	GEOTHERMAL OPTION	CAPITAL COSTS	SIMPLE PAYBACK (years)	ANNUALIZED COSTS		TOTAL 20-YEAR SAVINGS AND PAYBACK PERIOD (years)	
				CONVENTIONAL	GEOTHERMAL	Undiscounted	Present Value
ALAMOSA							
Adams State College	Heat exchanger, Artesian flow with pumping, on-site	$3,674,678	16	$720,535	$658,049	$15,336,331 (11-12)	$4,096,455 (18-19)
	Heat pump, Artesian flow with pumping, on-site	$2,111,387	9	$720,535	$476,912	$15,670,359 (9-10)	$4,194,979 (13)
Highway Dept. Building	Heat exchanger, Artesian flow with pumping, on-site	$722,800	47	$50,946	$138,145	($245,141) -	Negative
BUENA VISTA							
Colorado State Reformatory	Direct heating, pumped flow from Chalk Creek No. 1	$4,420,585	12	$1,159,497	$819,544	$27,202,360 (10)	$7,333,888 (15)
	Direct heating, gravity flow from Chalk Creek No. 2	$4,642,421	13	$1,159,497	$691,077	$31,063,857 (8-9)	$8,597,520 (13)
	Direct heating, gravity flow from Cottonwood	$4,117,445	11	$1,159,497	$562,871	$32,970,061 (7-8)	$9,215,012 (11-12)
Highway Dept Building	Heat pump, shallow well on-site	$34,253	12	$9,021	$6,600	$200,629 (11)	$53,800 (17)
BURLINGTON							
Highway Dept Building	Heat pump, shallow well on-site	$23,597	16	$4,779	$5,757	$62,852 (16-17)	$14,425 (>20)
DURANGO							
Fish Hatchery	Heat exchanger coupled to trunk line	$721,138	59	$40,170	$97,090	$798,258 (20)	$209,530 (>20)
Fort Lewis College	Heat pump coupled to trunk line	$8,365,417	28	$905,338	$1,388,312	$16,338,123 (16)	$4,220,014 (>20)
	Heat exchanger coupled to trunk line	$16,721,437	55	$905,338	$2,404,646	$13,784,921 (21)	$3,410,250 (>20)
Highway Dept Building	Heat exchanger coupled to trunk line	$1,543,087	44	$119,737	$215,442	$1,917,916 (19)	$497,658 (>20)
National Guard	Heat pump, shallow well on-site	$40,565	10	$14,327	$13,599	$192,606 (13)	$43,955 (19-20)
GLENWOOD							
Highway Dept Building	Heat exchanger, deep well on-site	$114,356	12	$29,974	$20,081	$697,883 (9-10)	$192,360 (14)
STEAMBOAT SPRINGS							
Highway Dept Building	Heat exchanger, deep well on-site	$39,232	11	$11,651	$6,882	$282,555 (10)	$76,773 (14)
	Heat pump, shallow well on-site, Artesian flow	$30,674	9	$11,651	$9,870	$170,900 (12)	$40,537 (17-18)

ACKNOWLEDGEMENT

This work was performed for and with the Colorado Geological Survey under Contract No. 34-11-00.