EGG-GTH--5599

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A PRELIMINARY CONCEPTUAL DESIGN
FOR GEOTHERMAL SPACE HEATING CONVERSION
OF SCHOOL DISTRICT 50 JOINT FACILITIES
AT PAGOSA SPRINGS, COLORADO
GTA REPORT NO. 67

MASTER

I. A. Engen

U.S. Department of Energy

Idaho Operations Office • Idaho National Engineering Laboratory

This is an Informal report intended for use as a preliminary or working document

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2/GTA REPORT NO. 62

I. A. Engen
reviewed by L. E. Donovan

Published November 1981

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ABSTRACT

This feasibility study and preliminary conceptual design effort assesses the conversion of Colorado School District 50 facilities--a high school and gym, and a middle school building--at Pagosa Springs, Colorado to geothermal space heating.

A preliminary cost-benefit assessment made on the basis of estimated costs for conversion, system maintenance, debt service, resource development, electricity to power pumps, and savings from reduced natural gas consumption concluded that an economic conversion depended on development of an adequate geothermal resource (approximately 150°F, 400 gpm).

Material selection assumed that the geothermal water to the main supply system was isolated to minimize effects of corrosion and deposition, and that system-compatible components would be used for the building modifications. Asbestos-cement distribution pipe, a stainless steel heat exchanger, and stainless steel lined valves were recommended for the supply, heat transfer, and disposal mechanisms, respectively.

A comparison of the calculated average gas consumption cost, escalated at 10% per year, with conversion project cost, both in 1977 dollars, showed that the project cost could be amortized over less than 20 years at current interest rates.

In view of the favorable economics and the uncertain future availability and escalating cost of natural gas, the conversion appears economically feasible and desirable.

CONTENTS

ABSTRACT	ii
FOREWORD	iv
SUMMARY	1
BACKGROUND	2
INTRODUCTION	4
CONCEPTUAL GEOTHERMAL CONVERSION	6
Resource Development	6
Disposal System	6
Heating Plant Modifications	7
Building Modifications	7
ESTIMATED COST AND PAYBACK	11
CONCLUSIONS AND RECOMMENDATIONS	15
Conclusions	15
Recommendations for Conversion of Existing Facilities and Providing Geothermal Supply and Disposal Systems	16
Implementation Procedure	16
Recommendations for Funding Aid	17
REFERENCES	18
APPENDIX A	19

FIGURES

1. Schematic of Geothermal Heat Conversion System	10
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TABLES

1. Chemical Analyses of Water From Pagosa Springs, Colorado	2
2. Conversion Costs	12
3. Comparison of Alternative Conversion Schemes	13

FOREWORD

The Geothermal Technical Assistance Program was developed under the premise that the majority of groups or individuals with available geothermal resources do not have the experience or manpower necessary to do a preliminary engineering and economic feasibility evaluation for geothermal energy projects. In order to disseminate technical information and to facilitate expanded use of geothermal energy resources, assistance was provided through FY-1981 in a consulting format on a first-come, staff-and-funds-available basis. Technical assistance can relate to conceptualization; engineering; economics; water chemistry implications for environmental, disposal, and material selection considerations; and planning and development strategies. This report is one of a series adapted from consultation provided to requestors either through in-house efforts or through limited efforts subcontracted to local engineering firms. The Geothermal Technical Assistance (GTA) reports in this series, which are listed below, will be available early in 1982 to those with interest in specific geothermal applications.

<u>GTA Report Number</u>	<u>EG&G Report Number</u>	<u>Title</u>
1.	EGG-GTH-5512	<u>Aquaculture Facility Potential at Boulder Hot Springs, Boulder, Montana</u>
2.	EGG-GTH-5521	<u>Preliminary Geothermal Disposal Considerations, State Health Laboratory, Boise, Idaho</u>
3.	EGG-GTH-5573	<u>Geothermal Conversion of Veterans Hospital, Boise, Idaho</u>
4.	EGG-GTH-5574	<u>Geothermal Applications for Highway Rest Areas</u>
5.	EGG-GTH-5575	<u>Geothermal Applications for a Tannery</u>
6.	EGG-GTH-5599	<u>Preliminary Conceptual Design for Geothermal Space Heating Conversion of School District 50 Joint Facilities at Pagosa Springs, Colorado</u>
7.	EGG-GTH-5617	<u>Selected Geothermal Technical Assistance Efforts (comprising short descriptions of ten space heating projects, five district heating projects, and three heat exchanger projects)</u>
8.	EGG-2137	<u>Geothermal Source Potential and Utilization for Methane Generation and Alcohol Production (subcontractor report)</u>
9.	EGG-2138	<u>Geothermal Source Potential and Utilization for Alcohol Production (subcontractor report)</u>
10.	EGG-2139	<u>Potential Geothermal Energy Applications for Idaho Elks Rehabilitation Hospital (subcontractor report)</u>
11.	EGG-2144	<u>Technical Assistance Report on a Geothermal Heating Utility for Lemmon, South Dakota (subcontractor report)</u>
12.	EGG-2145	<u>Economic Analysis for Utilization of Geothermal Energy by North Dakota Concrete Products Company (subcontractor report)</u>
13.	EGG-2146	<u>Geothermal Feasibility Analysis for Polo School District No. 29-2, South Dakota (subcontractor report)</u>

<u>GTA Report Number</u>	<u>EG&G Report Number</u>	<u>Title</u>
14.	EGG-2147	<u>Preliminary Feasibility Study of Heating and Cooling Alternatives for Nebraska Western College, Scottsbluff, Nebraska (contractor report)</u>
15.	EGG-2148	<u>Inventory of Thermal Springs and Wells Within a One-Mile Radius of Yucca Lodge, Truth or Consequences, New Mexico (subcontractor report)</u>
16.	EGG-2149	<u>Space Heating for Spa Facilities at Ojo Caliente, New Mexico (subcontractor report)</u>
17.	EGG-2150	<u>Space Heating for Office Building at Glenwood Springs, Colorado (subcontractor report)</u>
18.	EGG-2151	<u>District Heating for Subdivision in Dickinson, North Dakota (subcontractor report)</u>
19.	EGG-2152	<u>Space Heating for Subdivision in Truth or Consequences, New Mexico (subcontractor report)</u>
20.	EGG-2153	<u>Space Heating for Veterans Administration Medical Center, Marlin, Texas (subcontractor report)</u>
21.	EGG-2154	<u>District Heating for Subdivision in Castle Rock, Colorado (subcontractor report)</u>
22.	EGG-2155	<u>Space Heating for Twin Lakes School Near Gallup, New Mexico (subcontractor report)</u>
23.	EGG-2156	<u>Reservoir Data for Electrical Generation at Gila Hot Springs, New Mexico (subcontractor report)</u>

SUMMARY

The objective of this feasibility and preliminary conceptual design effort was to assess the conversion of the Colorado School District 50 facilities at Pagosa Springs, Colorado to geothermal space heating.

The school district facilities considered for the conversion consist of a high school and gym, and a middle school building.

In order to evaluate the feasibility of the conversion and develop a preliminary conceptual design, a preliminary cost-benefit assessment was made on the basis of estimated costs for conversion, system maintenance, debt service, resource development, electricity to power pumps, and savings from reduced natural gas consumption. Economic implementation of the conversion depended on development of an adequate geothermal resource (approximately 150°F, 400 gpm).

Material selection assumed that the geothermal water to the main supply system was isolated to minimize effects of corrosion and deposition, and that system-compatible components would be used for the building modifications. Asbestos-cement distribution pipe, a stainless steel heat exchanger, and stainless steel lined valves were recommended for the supply, heat transfer, and disposal mechanisms, respectively.

Using an average heating load factor and an estimated 9000 heating degree days per year for the Pagosa Springs area, the amount of heat required for an average heating season was calculated, and this was then converted to natural gas cost by applying an 83% overall heating plant efficiency factor and the most recent natural gas rates as shown on school district billing. A comparison of this average gas consumption cost, escalated at 10% per year, with conversion project cost, both in 1977 dollars, shows that the project cost can be amortized over less than 20 years at current interest rates.

In view of the favorable economics and the uncertain future availability and escalating cost of natural gas, the conversion appears economically feasible and desirable.

BACKGROUND

On the basis of information obtained from Dr. R. L. Pearl of the Colorado Geological Survey Office and from Dr. G. Keller and Mr. R. Crewdson of the Colorado School of Mines, it was understood that the character and extent of the reservoir is largely undefined. However, geochemical models indicated that a reservoir temperature of 300 to 400°F was likely. Crewdson estimated that Pagosa Hot Springs should issue 700 gpm with a temperature of approximately 140°F.¹ An analysis of the water showed total dissolved solids of 3350 ppm, SiO₂ predicted reservoir temperature of 329°F, and Na-K-Ca predicted reservoir temperature of 532°F. This wide a spread in predicted temperature placed the reservoir temperature in question. The USGS had estimated² a reservoir temperature of about 300°F and a reservoir volume of about 725,000 gallons. Some data on geothermal waters at Pagosa Springs are given in Table 1.

TABLE 1. CHEMICAL ANALYSES OF WATER FROM PAGOSA SPRINGS, COLORADO (in ppm)

	Discharge (gpm)	Temp. (°F)	Silica (Si)	Sodium (Na)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Chloride (Cl)	Sulfate (SO ₄)	Bicarbonate (HCO ₃)
1. ³	600	162	68	525	370	247	17	180	1504	636
2. ⁴			58	890	91	280	13		1560	340

It was learned during a site visit that the Pagosa Springs resource supplied heat for resort facilities, the county courthouse, a local drug store, a church, and a few other private users. The courthouse was supplied by an artesian well with sufficient flow to heat the two-story courthouse without circulation pumps. No corrosion or deposition problems had been reported for the courthouse heating system, although these problems had been reported by other users. Wide variations in water temperature between well sites, which were close together, had been reported. The deepest well in the area was about 700 feet in depth. Surface disposal of geothermal effluent was by discharge to a river. Since this effluent enters the Colorado River system, surface disposal was not thought to be a viable discharge method for any significantly increased volume of effluent.

From available information, it seemed reasonable to assume the existence and availability of 150°F geothermal water at a flow rate of 400 gpm (economics of the conversion required a resource with at least this temperature and flow). The preliminary conceptual design was thus based on this assumption.

INTRODUCTION

School District 50 facilities at the Pagosa Springs site included a high school, gymnasium, a middle school, and library building. Only the high school, gymnasium, and middle school were considered for the conversion to geothermal space heating.

These buildings were heated by a gas-fired boiler. The older middle school building had a hot water system using finned-tube convection units and exposed pipe radiation, in series. Gas-fired unit heaters were used in the new high school and gymnasium. The middle school building had been heated with 120 to 130°F geothermal water obtained from a well on school district property until about 15 years ago, when the system was included in the gas-fired system because of corrosion problems and high maintenance cost associated with the direct use of the geothermal water, and because of uneven heat distribution from the series piping arrangement and limited capacity due to the well head temperature. During inclusion of the middle school building in the gas-fired system, the series piping was modified into a four-zone system with individual circulation pumps. The maximum space heat requirements for the high school, gymnasium, and middle school were found to be about 2,000,000 Btu/hr.

The existing school district well appeared inadequate to supply the needs of the heating system; drilling a new well and using the existing well for reinjection was recommended.

Inspection of the existing heating systems showed them to be in good condition. Maintenance cost were reportedly low. Heat transmission in the older building was probably impaired by several coats of light-colored paint on the exposed pipe runs. There appeared to be adequate space to modify the heating systems so as to permit a conversion using the geothermal water resource. Inclusion of a heat exchanger was necessary to allow a closed circulation system and to minimize the effects of corrosion and deposition. It was recommended that the existing distribution lines be used since they were deemed adequate to carry the required water flows.

The estimated heat load was developed from the installed design capacity of the existing system, recent annual utility billings, and estimated degree-day data. From these data, a preliminary conceptual design for the conversion was developed.

Component cost was estimated on the basis of current vendor prices. All components were off-the-shelf or catalogue items, and appropriate costs for less-than-truckload lots were employed. Allowance was made for installation cost and for subcontractor overhead and profit.

No attempt was made to redesign the existing heating system; the suggested modifications were necessary in order to use the geothermal water effectively. It was expected that the existing system components would be used where possible to minimize cost, and that the existing gas-fired system would be retained for system back-up.

CONCEPTUAL GEOTHERMAL CONVERSION

Resource Development

It was recommended that a new well be drilled on school district property in order to develop an adequate resource. In view of the sparsity of information concerning the reservoir, some resource assessment work had to be done. It was understood that the Colorado School of Mines, with ERDA funding, would do some geothermal resource assessment work at Pagosa Springs beginning in the summer of 1977. It was recommended that a portion of this work be done at the school site as an aid in locating the optimum well site. The new well had to be located to prevent interaction with the existing well, which was being considered as a reinjection well.

For costing purposes, it was assumed that the new well will be an 8-in. cased well drilled to a depth of 1000 ft. The pump was assumed to be set at 200 ft and to have automatic controls. Required pumping capacity was estimated to be 25 to 30 hp, which includes capacity for reinjection or surface discharge and an allowance for pressure drop across a heat exchanger.

In view of the reported chemistry of the local geothermal water, we recommended using a 6-in. asbestos-cement supply line to transport water from the well to the heating plant. Since the well location was undetermined at that time, a location 185 ft from the heating plant was assumed for costing purposes. This was approximately the distance between the existing well and the heating plant. The supply line required two gate valves; 6-in., stainless-steel-lined, steel-body valves were recommended.

Disposal System

It was not known if surface disposal, as used in the past, was still an environmentally acceptable disposal method. Since the effluent would find its way to the Colorado River System under this method, we assumed that reinjection of the spent geothermal fluid would be required, and we recommended using the existing well for this purpose. Stainless-steel-lined, steel-body gate valves and asbestos-cement pipe were recommended for this application. In estimating cost, we assumed 185 ft of pipe with two valves.

Surface discharge would have required transporting the spent geothermal water to the nearby river, a distance of about 1800 ft. Since initial effluent temperature was to be approximately 130°F, discharge to the river would have required a conduit for protection of the public--at costs approximating or exceeding those of reinjection. This alternative scheme was rejected as being environmentally unsound and not cost beneficial.

Heating Plant Modifications

We recommended installing a 2,000,000 Btu/hr stainless steel heat exchanger with the necessary piping and valves, with the existing gas-fired system to be used as a backup or supplement to the geothermal system. A plate-type stainless steel heat exchanger was recommended for this application because its inherent ease of maintenance would minimize operating expense associated with the Pagosa Springs geothermal water. Maintenance of the supply system with the plate-type exchanger should only consist of circulating a commercially available cleaning solution to remove deposition in the system on a scheduled basis and dismantling the exchanger for more rigorous cleaning as necessary.

Circulation system water temperature at the heat exchanger outlet was estimated to be 140°F. Cost of the plate-type stainless steel heat exchanger was below that of a conventional steel tube and shell heat exchanger of the same 2,000,000 Btu/hr capacity. The space required for the heat exchanger was about 3 x 8 x 5 ft. Estimated cost of the plate-type heat exchanger was based on an A.P.V. Co. Inc.^a unit.

Building Modifications

The existing supply and return lines servicing the high school and middle school buildings were sufficient to carry the estimated flow. Additional circulation pumping capacity was necessary, however, since maximum demand flow rates to each of these buildings will approach 200 gpm.

a. A.P.V. Co. Inc., Tonawanda, NY 14150.

Before conversions the heating systems were supplied with 180°F water; the maximum heat load of 2,000,000 Btu/hr was distributed with about 925,000 Btu/hr each to the high school and middle school and about 150,000 Btu/hr to the gym.

In converting to a water temperature of 140°F, the heating capacity of the convection units and exposed pipe systems had to be increased by about 40% to equal the performance of the 180°F water system; gas-fired unit heaters were to be replaced with hot water units and/or fan-coil units. It was proposed that existing convection units be used where possible and that others be added for extra capacity. It was also proposed that fin tube convectors be installed in conjunction with the exposed piping system to obtain the extra heating capacity needed for that portion of the system. It was suggested that the efficiency of the exposed pipe system could be improved if the pipe were unpainted, or, if paint build-up was not severe, by painting the exposed pipe with an appropriate black or dark colored paint.

The cost of additional convection units was estimated by derating Type S Dunham-Bush/Webster (50-4 x 5 fin/in) Valvector^a units to 140°F performance, resulting in a heat rate of about 700 Btu/ft at design conditions. It was estimated that the high school would require about 375 ft of convector installation and the middle school about 480 ft. In addition, the high school conversion would require unit heaters with a combined rating of 237,000 Btu/hr at 140°F to replace the previously used gas-fired units. The estimated cost of this replacement was based on two McQuay^b UHH-086A and one UHH-044A units.

The cost of converting the gymnasium was estimated to be 20% of the high school conversion cost; the maximum heat load for the gymnasium was about 17% of the high school heat load.

a. Dunham-Bush, Inc., West Hartford, Connecticut

b. McQuay Division, McQuay-Perfex, Inc., Minneapolis, Minnesota

A schematic drawing of the proposed geothermal supply, heat transfer, and disposal system is shown in Figure 1.

Figure 1. Schematic of geothermal heat conversion system.

ESTIMATED COST AND PAYBACK

Where possible, conversion costs were based on current vendor prices for materials and components. The cost of pumps to satisfy the additional pumping requirements due to the conversion were estimated to be \$100/hp for circulation and disposal, and \$500/hp for the well. Backup circulation pumping was included in the pump costs. It was assumed that existing distribution and circulation pumps were used in the conversion and that no cost was incurred for their use. Engineering and design costs were estimated to be 25% of capital equipment cost. A 15% contingency factor was applied to total project cost to account for unforeseen costs not included in the analysis. Annual maintenance cost was estimated to be 3% of capital equipment cost, and the annual operating labor cost incurred because of the project was estimated to be \$280. Installed costs included 25% for contractor overhead and profit.

No cost was included for an environmental impact study; it was assumed that environmental impact assessment requirements would be minimal in view of the prior and existing use of the local geothermal resource, the school district ownership of the site, and the desirability of developing alternative energy resources.

Cost estimates for conversion components and variable cost elements are given in Table 2.

Consideration was given to reducing costs by excluding the gymnasium from the conversion, by decreasing the depth of the production well to be developed from 1000 to 500 ft, and by using surface disposal rather than reinjection of the geothermal effluent. It was found that exclusion of the gymnasium would not have greatly reduced overall cost, and that surface disposal would have materially increased costs--assuming that pipe and installation costs would have been significantly greater than the cost of using the existing well for reinjection. Pumping requirements for surface disposal appeared to approximate the reinjection pumping requirements, resulting in essentially the same cost for pumping equipment and operation for either disposal scheme.

TABLE 2. ESTIMATED CONVERSION COSTS (1977)

Item	Material or Specification Basis	Number Amount	Installed Cost (\$)
1000 ft well or 500 ft well	8-in. casing	1	35,000 17,500
Distribution pipe	6-in. cement-asbestos	185 ft	3,900
Valves	Type 304 SS lined	2	2,600
Heat exchangers	Type 304 SS plate-type	1	6,000
Disposal Reinjection Surface	1500 A of concrete-asbestos pipe & 1 valve		4,500 10,400
High school Convectors	700 Btu/fr-hr @ 140°F, 3 ft/sec	375 ft	9,500
Unit heaters	270,000 Btu/hr @ 140°F	3	2,000
Gym @ 20% of high school cost			2,300
Middle school convectors		480 ft	12,500
Annual operating labor			280
Engineering and design	@ 25% of capital equipment		
Annual maintenance	@ 3% of capital equipment		
Pumps, circulation, disposal	@ \$100/hp		
Pump, well	@ \$500/hp		
Contingency	@ 15% of total project cost		
Design life of facility	25, 20, 15 yrs		

Results obtained from examination of the various conversion schemes are shown in Table 3.

TABLE 3. COMPARISON OF ALTERNATIVE CONVERSION SCHEMES (Costs to nearest \$100)

Well Depth (ft)	Scheme		Cost (\$)	Amortization						
	Disposal	Gym	Capital Equipment	Total	15 Years ^a		20 Years ^b		25 Years ^b	
					Payment (\$/yr)	Payback Initial Cost (yr)	Payment (\$/yr)	Payback Initial Cost (yr)	Payment (\$/yr)	Payback Initial Cost (yr)
500	Reinjection	Included	71,200	102,300	11,200	12.1	9,700	17.5	8,800	18.1
500	Reinjection	Excluded	67,500	97,000	10,600	13.2	9,200	18.9	8,300	19.6
500	Surface	Included	77,100	110,800	12,200	12.8	10,500	18.2	9,500	18.9
500	Surface	Excluded	73,400	105,500	11,600	14.0	10,000	19.7	9,000	20.5
1000	Reinjection	Included	88,700	127,500	14,000	14.0	12,000	19.6	10,900	20.4
1000	Reinjection	Excluded	85,000	122,100	13,400	15.2	11,500	20.9	10,000	22.1
1000	Surface	Included	94,600	136,000	15,000	14.6	12,800	20.2	11,700	21.1
1000	Surface	Excluded	90,900	130,000	14,300	15.9	12,300	20.5	11,200	22.8

a. Initial natural gas and electricity costs: \$1.40/million Btu & 3.7¢/kwh, escalated at 10%/yr.

b. Initial natural gas and electricity costs: \$0.97/million Btu & 4.0¢/kwh, escalated at 10%/yr.

Payback calculations for the conversion project were based on project cost, maintenance and operating costs attributed to the conversion, debt service at an interest rate of 7%, electrical costs for the additional pumping requirements, and credit taken for reduced use of natural gas for space heating. Cost of electricity and natural gas were assumed to escalate at 10%/yr.

Payback was computed using the computer code GEOTHE, which is an extension of the code GEOTH, developed for the Colorado Energy Institute. Modifications were made to the original code in order to model this conversion problem more adequately.

Selection of an appropriate conversion scheme and amortization schedule required consideration of two important consequences of the length of time for payback of the initial investment:

1. Fuel savings, due to the conversion, would effectively level the cost of energy for heating when $1/4$ of the time required for payback was reached.
2. Annual fuel savings would approximately equal the annual operating and debt service costs when $1/2$ of the payback period was covered, and would exceed these costs thereafter.

Input values for conversion component costs were derived from values in Table 2. Other input values were from information supplied by School District No. 50, Joint, Pagosa Springs, Colorado; equipment manufacturers; and estimated degree-day data for Pagosa Springs. It should be noted that the parameter listed as outside design temperature is the temperature of the transmission pipe environment-in this case, design soil temperature (below the frost line). A representative listing from GEOTHE is shown in Appendix A.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The following conclusions were derived from the foregoing study.

1. Although information about the local geothermal resource is deficient, there is a very high probability for development of an adequate geothermal supply system.
2. The nature of the local geothermal water requires use of corrosion-resistant materials.
3. Because of the significant well cost involved in developing the geothermal energy resource, the costs of converting to the use of this resource are relatively high. However, the economics show that the conversion is economically feasible if the well costs do not greatly exceed the assumed values. A production well 500 ft deep (rather than 1000) would improve the conversion economics.
4. The total conversion cost can be amortized over 20 years or less. This assumes that the economic lifetime of the middle school building is the same as the remainder of the converted system. Because of its apparent age, this seems unlikely, but if a replacement were built on the same site, it could take advantage of geothermal space heating.
5. The initial cost savings to be derived by excluding the gymnasium from the conversion would soon be lost to fuel costs and would lead to a significant increase in amortization cost.
6. Although surface disposal of geothermal effluent is being employed by other users and although the school district has previously used this disposal method, it is more environmentally acceptable and cost-effective to use the existing well on school property for reinjection.

7. The technology necessary to effect the conversion already exists, and the necessary equipment items are available as off-the-shelf or catalog items.

Recommendations for Converting Existing Facilities and Providing Geothermal Supply and Disposal Systems

The following recommendations were made:

1. Drill a new 8-in. cased well and install well head equipment.
2. Install a new 6-in. cement-asbestos supply line with Type 304 stainless steel lined, steel bodied valves for flow control. Use the same valve and pipe materials in the disposal system. Use the existing well for reinjection.
3. Use the existing gas-fired boiler system for space heating backup. Install a Type 304 stainless steel plate-type heat exchanger rated at 2,000,000 Btu/hr at design conditions in parallel with the existing boiler system. Use Type 304 stainless steel fittings on the geothermal supply side of the heat exchanger.
4. Use the existing high school and middle school distribution lines and the existing heating systems insofar as possible. Install the necessary fin-tube convectors and unit heaters or fan coil heaters to provide the necessary additional heating capacity for the middle school, high school, and gym. (It appeared that only convectors were required in the middle school.)

Implementation Procedure

The following procedure for implementing the conversion was recommended:

1. Proceed with the development of an adequate geothermal resource. Prior to a drilling operation, log the existing well to determine, if possible, whether or not there is a near-surface strata of sufficiently hot

water that may be diluted by surface or subsurface waters of lower temperature. Integrity of the existing well casing will affect the results obtained and may impact the use of this well for disposal.

2. Determine the feasibility of surface disposal, make a more accurate cost estimate for this method, and ascertain the necessity for an environmental impact assessment. Evaluate the existing well for use as a reinjection well, and select the appropriate method for disposal.
3. If an adequate geothermal energy resource is obtained, proceed with the conversion by developing a final conceptual design based on the available resource temperature, flow, and chemical analyses. Obtain cost estimates, and determine an appropriate amortization scheme.

Recommendations for Funding Aid

The following potential funding aids were recommended:

1. Investigate the possibility of obtaining resource assessment work as part of the ERDA^a-funded work to be done at Pagosa Springs by the Colorado School of Mines.^b
2. Investigate the possibility for obtaining State of Colorado, ERDA, or Economic Development Administration funding or support for well drilling and other geothermal conversion costs.

a. Now the U.S. Department of Energy.

b. Performed in 1977.

REFERENCES

1. R. Crewdson, unpublished report on water from Pagosa Hot Springs.
2. D. E. White and D. L. Williams (eds.), Assessment of Geothermal Resources of the United State - 1975, Geological Survey Circular 726, 1975.
3. C. R. Nichols and K. W. Hollenbaugh, Geological Aspects of the National Potential for Non-Electrical Utilization of Geothermal Resources, ANCR-1213, June 1975. (Water from Pagosa Hot Springs.)
4. "Water from School District 50 Well," unpublished INEL Data.
5. L. W. Nannen, et al., An Investigation of the Technical and Economic Feasibility of Using Low Temperature Geothermal Sources in Colorado, Final Report to Colorado Energy Research Institute, Project No. 022-03, November 1975.

APPENDIX A

REPRESENTATIVE DATA FROM COMPUTER CODE "GEOHE"

SECRET
CONFIDENTIAL - SECURITY INFORMATION

PROGRAM GEOTHE 2/10/77
 SCH-D PAG SP CO - GEO HT CONV (ASB-CEM PIPE, D-REIN, 500'WELL, INC GYM)

TECHNICAL INPUT DATA

TEMPERATURE WORKING FLUID AT SOURCE, DEG F	=	150.00
DESIGN TEMPERATURE, DEG F	=	50.00
TEMPERATURE OF WORKING FLUID LEAVING USER, DEG F	=	140.00
HEAT CAPACITY OF WORKING FLUID, BTU/LB-F	=	1.000000
DENSITY OF WORKING FLUID, LB/CU.FT	=	62.400000
WORKING FLUID VELOCITY, FT/SEC	=	5.000000
THERMAL CONDUCTIVITY OF INSULATION, BTU-IN/HR-SQ.FT-F	=	3.000000
THICKNESS OF SOIL INSULATION, INCHES	=	60.00
CEMENT-ASB PIPING ROUGHNESS, FT	=	.001000
NEW DISTRIBUTION PIPING, FT	=	185.00
SYSTEM COMPONENT LOSSES, FT OF WATER	=	95.00
PUMPING LIFT AT WELL, FT	=	226.00
MAXIMUM OUTPUT PER WELL, MMBTU	=	3.00
DEGREE DAYS PER YEAR (AVERAGE)	=	9000.00
DEGREE DAYS PER DAY, WORST CONDITIONS,	=	60.00
USER LOAD DURING AVERAGE YEAR, MMBTU/YR	=	7070.00
USER LOAD UNDER WORST CONDITIONS, MMBTU/HR	=	2.00

ECONOMIC INPUT DATA

DESIGN LIFE OF PROJECT, YRS	=	20
COST OF MONEY, FRACT	=	.07
COST OF DRILLING AND COMPLETION PER WELL, \$	=	17500.00
COST OF DISTRIBUTION PIPING, \$/FT	=	24.33
COST OF INSULATION, \$/FT	=	0.00
COST OF VALVES, FITTINGS, CONTROLS, \$	=	0.00
COST OF FLUID DISPOSAL SYSTEM, \$	=	4500.00
COST OF PUMPS INCL. CIRC-PUMP BACKUP, \$	=	0.00
COST OF HEAT CONVERSION SYSTEM OR RETFIT, \$	=	26250.00
COST OF HEAT EXCHANGER, \$	=	6000.00
COST OF ENGINEERING AND DESIGN, \$	=	0.00
COST OF ENVIRONMENTAL IMPACT STUDY, \$	=	0.00
COST OF CONTINGENCY, FRAC OF PROJECT COST	=	.15
PRESENT COST OF ELECTRICITY, (CENTS/KW-HR)	=	3.7000
PROJECTED ANNUAL ELECTRICAL COST ESCALATION, (FRACT)	=	.1000
NET CONVERSION EFFICIENCY OF FOSSIL SYSTEM, (FRACT)	=	.8330
PRESENT COST OF NATURAL GAS OR OTHER FOSSIL FUEL, (CENTS/MMBTU)	=	96.0000
PROJECTED ANNUAL GAS COST ESCALATION, (FRACT)	=	.1000
ANNUAL MAINTENANCE COSTS, (FRACT OF EQUIPMENT COST)	=	.0300
OPERATING AND SUPERVISORY LABOR RATE, \$/HR	=	7.0000
OPER & SUPV LABOR ASSIGNED TO PROJECT, HRS/YR	=	40.0000
OPERATING AND SUPV LABOR COST, INPUT, \$/HR	=	280.0000
TAX RATE (FRACTION OF PLANT EQUIPMENT)	=	0.0000

YEAR	FUEL SAVINGS, \$/YR	ANNUAL OPERATING COST, \$/YR	CUMULATIVE SAVINGS, \$
1	8147.9	14789.8	-4146.1
2	8962.7	15061.4	-7574.2
3	9859.0	15360.2	-10218.0
4	10844.9	15688.9	-12004.6
5	11929.3	16050.5	-12854.2
6	13122.3	16448.2	-12679.5
7	14434.5	16885.6	-11385.1
8	15878.0	17366.9	-8866.3
9	17465.7	17896.2	-5008.4
10	19212.3	18478.5	313.9
11	21133.6	19119.0	7238.1
12	23246.9	19823.6	15914.8
13	25571.6	20598.6	26508.9
14	28128.8	21451.1	39201.1
15	30941.6	22388.9	54189.5
16	34035.8	23420.4	71690.9
17	37439.4	24555.1	91943.3
18	41183.3	25803.3	115207.2
19	45301.6	27176.3	141768.2
20	49831.8	28686.6	171939.7

AVERAGE GEOTHERMAL ENERGY COST, \$/MMBTU = 2.808

AVERAGE NATURAL GAS COST, \$/MMBTU UTILIZED = 3.300

PRESENT COST OF GEOTHERMAL ENERGY, \$/MMBTU = 1.474

TECHNICAL OUTPUT DATA

HEAT LOSS IN DISTRUBUTION PIPING, (BTU/HR)	=	89626.188
TEMPERATURE OF WORKING FLUID DEL. TO USER (DEG F)	=	149.552
DISTRIBUTION PIPE DIAMETER,(INCHES)	=	5.714
WORKING FLUID FLOW RATE AT MAX LOAD, (GPM)	=	4001.12
PRESSURE DROP DUE TO FRICTION, PSIG	=	1.550
PRESSURE DROP DUE TO SYSTEM COMPONENTS, PSIG	=	41.167
PRESSURE DROP TOTAL PSIG	=	140.650
PUMPING HP REQUIRED (WITHOUT BACKUP) HP	=	27.348
PUMPING HP , WELL HP	=	23.190
PUMPING HP, CIRC, BACKUP AND DISPOSAL, HP	=	8.316
PUMPING HP (TOTAL INCL. BACKUP) HP	=	31.506
NUMBER OF WELLS REQUIRED	=	1

ECONOMIC OUTPUT DATA

CAPITAL RECOVERY FACTOR	=	.0944
TOTAL CAPITAL EQUIPMENT COST, \$	=	71177.51
LOAD FACTOR	=	.4110
PAYOUT TIME, YEARS	=	17.45
COST OF DRILLING AND COMPLETING WELLS, \$	=	17500.00
COST OF DISTRIBUTION PIPING SYSTEM, \$	=	4501.05
COST OF INSULATION, \$	=	0.00
COST OF VALVES, FITTINGS, CONTROLS, \$	=	0.00
COST OF FLUID DISPOSAL SYSTEM, \$	=	4500.00
COST OF CIRC, BACKUP, DISPOSAL PUMPS, \$	=	831.65
COST OF WELL PUMP OR TOT. PUMP COST INPUT, \$	=	11594.81
COST OF HEAT CONVERSION SYSTEM, \$	=	26250.00
COST OF HEAT EXCHANGER, \$	=	6000.00
COST OF ENGINEERING AND DESIGN, \$	=	17794.38
COST OF ENVIRONMENTAL IMPACT STUDY, \$	=	0.00
COST OF CONTINGENCY, \$	=	13345.78
ANNUAL SUPERVISORY AND LABOR COSTS, \$	=	280.00
ANNUAL TAX COSTS, \$	=	0.00
ANNUAL MAINTENANCE COST, \$	=	2135.33
ANNUAL ELECTRICAL PUMPING COST, 1ST YR \$	=	2716.39
TOTAL INITIAL INVESTMENT, \$	=	102317.66
ANNUAL FIXED CHARGES, PRINCIPAL AND INTEREST, \$	=	9658.06