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MASTER

Economic Analysis for Utilization of Geothermal Energy by North Dakota Concrete Products Co.

L. L. Zink,
TPI, Inc.

February 1982

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**Prepared for EG&G Idaho, Inc.
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Idaho Operations Office
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PREFACE

This report was prepared for EG&G Idaho by TPI, Inc. on Subcontract No. K-7791 under the Department of Energy's Outreach Program. It is now being reissued without modification as an

EG&G Formal report in order to make it available to others that may be interested in this geothermal application.

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	<i>Aquaculture Facility Potential at Boulder Hot Springs, Boulder, Montana</i>
2.	EGG-GTH-5521	<i>Preliminary Geothermal Disposal Considerations, State Health Laboratory, Boise, Idaho</i>
3.	EGG-GTH-5573	<i>Geothermal Conversion at Veterans Hospital, Boise, Idaho</i>
4.	EGG-GTH-5574	<i>Geothermal Applications for Highway Rest Areas</i>
5.	EGG-GTH-5575	<i>Geothermal Applications for a Tannery</i>
6.	EGG-GTH-5599	<i>Preliminary Conceptual Design for Geothermal Space Heating Conversion of School District 50 Joint Facilities at Pagosa Springs, Colorado</i>
7.	EGG-GTH-5617	<i>Selected Geothermal Technical Assistance Efforts (comprising short descriptions of ten space heating projects, five district heating projects, and three heat exchanger projects)</i>
8.	EGG-2137	<i>Geothermal Source Potential and Utilization for Methane Generation and Alcohol Production (subcontractor report)</i>
9.	EGG-2138	<i>Geothermal Source Potential and Utilization for Alcohol Production (subcontractor report)</i>
10.	EGG-2139	<i>Potential Geothermal Energy Applications for Idaho Elks Rehabilitation Hospital (subcontractor report)</i>
11.	EGG-2144	<i>Technical Assistance Report on a Geothermal Heating Utility for Lemmon, South Dakota (subcontractor report)</i>
12.	EGG-2145	<i>Economic Analysis for Utilization of Geothermal Energy by North Dakota Concrete Products Company (subcontractor report)</i>

<u>GTA Report Number</u>	<u>EG&G Report Number</u>	<u>Title</u>
13.	EGG-2146	<i>Geothermal Feasibility Analysis for Polo School District No. 29-2, South Dakota (subcontractor report)</i>
14.	EGG-2147	<i>Preliminary Feasibility Study of Heating and Cooling Alternatives for Nebraska Western College, Scottsbluff, Nebraska (contractor report)</i>
15.	EGG-2148	<i>Inventory of Thermal Springs and Wells Within a One-Mile Radius of Yucca Lodge, Truth or Consequences, New Mexico (subcontractor report)</i>
16.	EGG-2149	<i>Space Heating for Spa Facilities at Ojo Caliente, New Mexico (subcontractor report)</i>
17.	EGG-2150	<i>Space Heating for Office Building at Glenwood Springs, Colorado (subcontractor report)</i>
18.	EGG-2151	<i>District Heating for Subdivision in Dickinson, North Dakota (subcontractor report)</i>
19.	EGG-2152	<i>Space Heating for Subdivision in Truth or Consequences, New Mexico (subcontractor report)</i>
20.	EGG-2153	<i>Space Heating for Veterans Administration Medical Center, Marlin, Texas (subcontractor report)</i>
21.	EGG-2154	<i>District Heating for Subdivision in Castle Rock, Colorado (subcontractor report)</i>
22.	EGG-2155	<i>Space Heating for Twin Lakes School Near Gallup, New Mexico (subcontractor report)</i>
23.	EGG-2156	<i>Pumping Tests at Well Campbell Et Al. No. 2, Gila Hot Springs, Grant County, New Mexico (subcontractor report)</i>
24.	EGG-GTH-5739	<i>Geothermal Deicing of Bridge Structures</i>
25.	EGG-GTH-5740	<i>Assessment of a Geothermal Application at Tucson, Arizona</i>
26.	EGG-GTH-5741	<i>Heat Pump Systems for Spring Creek, Montana</i>

ABSTRACT

North Dakota Concrete Products Company uses a steam curing process that accelerates the concrete curing so that 28-day strength is obtained within 24 hours. The cost of energy required to accomplish this is significant, amounting to approximately \$80,000 in 1980. The present boilers are oil fired. Recently, fuel oil prices have increased substantially. Further, supply shortages in the past have threatened plant production.

The purpose of this study was to evaluate the economic feasibility of using deep formation warm

water as an alternative energy source. A water-to-water heat pump system to replace the existing boiler system was investigated. This report discloses TPI, Inc. economic and engineering findings for this particular potential geothermal application. The operating cost savings of the geothermal system over the operating costs of the existing oil-fired system would be insufficient to provide an acceptable rate of return on the investment at today's cost of money.

ECONOMIC ANALYSIS FOR UTILIZATION OF

GEOTHERMAL ENERGY

BY

NORTH DAKOTA CONCRETE PRODUCTS CO.

BISMARCK, N.D.

SUBMITTED BY:

TPI, INC.

P.O. BOX 1357

BISMARCK, N.D. 58502

AUGUST 1981

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I. INTRODUCTION

North Dakota Concrete Products (N.D.C.P.) Company has been operating in the Bismarck area for over 50 years producing concrete products such as concrete culverts, pre-stressed bridge beams, pilings, manhole covers and miscellaneous items. It now employs up to 80 full time people. In the first full year of production in their new plant near Menoken, North Dakota in 1980, over 21,000 tons of concrete products were produced.

At this plant, it is necessary to utilize a steam curing process which accelerates the concrete curing so that 28 day strength is obtained within 24 hours. The cost of energy required to accomplish this is significant, amounting to approximately \$80,000 in 1980.

The present boilers are oil fired. Recently, fuel oil prices have increased substantially. Further, past experiences have dealt with supply shortages which threatened plant production.

The purpose of this study is to evaluate the economic feasibility of utilizing deep formation warm water as an alternate energy source. A water to water heat pump system was investigated to replace the existing boiler system. This report discloses TPI, Inc. economic and engineering findings for this particular potential geothermal application.

II. WATER SUPPLY

Presently, the plant's water supply is from the Fox Hills Formation. This well is approximately 300 feet deep. A water sample was taken and a chemical analysis was made by the North Dakota State Health Department Laboratories (See Page 12). The temperature of the water from this aquifer was recorded at 52°F.

A potential geothermal source is the Madison Formation. It is approximately 5,400 feet below the ground surface and has a water temperature estimated to be near 120°F. The potential for using this formation for a geothermal source is severely limited by the quality, expected to be in the neighborhood of 250,000 to 350,000 p.p.m. TDS level. Another limiting factor is drilling costs estimated at \$100/foot.

Another formation which has a greater potential for mining of geothermal heat is the Inyan Kara Formation - a portion of the Dakotas Sandstone Formation. It underlays a large area extending north to Canada, west to the Rocky Mountains, south into mid South Dakota and east to Valley City, North Dakota. At the North Dakota Concrete Products plant location, geothermal maps indicate the formation is approximately 250 feet thick and is approximately 2,900 feet from the ground surface to the top of the formation. The water temperature is estimated at 97°F. and a 60' artesian head is predicted at the well head. The water is estimated to have a TDS level below 2,500 p.p.m. For these reasons - this aquifer was studied as the potential geothermal source.

From drilling contractors it was determined an 8" well would be needed in order to supply between 150 and 300 GPM from the formation. A 5" well was recommended for the purpose of reinjecting the water into the Dakota Sandstone Formation. Flow rates in excess of 300 GPM would improve operating characteristics of the heat pump system but would involve much

greater pumping costs and larger, more expensive wells. The expected yields, pumping costs, capital costs, and other pertinent information are itemized in Tables 2, 3 and 8.

Various methods of disposing the geothermal waste water were considered. The possibility of surface drainage or exhausting into an evaporating pond were environmentally ruled out because of water quantity and quality. Injecting the geothermal water into the existing Fox Hills Well is an option. However, in spite of similar water qualities in the Fox Hills and Dakota Sandstone Formations, it would be extremely difficult and costly to prove that no long term adverse effects on the Fox Hills Formation would occur. The only alternative considered was to reinject the geothermal waste water back into the Dakota Sandstone Formation.

III. EXISTING BOILERS -

The steam curing system now used at the concrete plant employs four oil fired boilers. They also provide steam for some space heating. A 500,000 BTUH boiler is used in a pre-stress plant, a 1,200,000 BTUH boiler is used in the Wet Cast Plant and two 500,000 BTUH boilers are used in the Pipe Plant kilns.

Refer to Table 1 for boiler specifications.

These boilers operate during the evening hours. Time clocks shut down the boilers when the heat of hydration and residual heat in the concrete and the space around are sufficient to complete the concrete curing process.

The pre-stress boiler often operates 15 hours per day. The Wet Cast and Pipe Plant boilers operate six to eight hours daily. The plant is generally in operation five days per week. The pre-stress plant is usually used nine months out of the year while the pipe plant operates close to twelve months - this varies significantly however, depending on work load.

The steam produced by the boilers is exhausted into the kilns or under tarps covering the forms. The condensed steam is not recycled, therefore 100% makeup water is required to the boilers.

The capacities of the boilers were determined in a six day monitoring test of each boiler. Water and fuel consumption, hours of operation, and total concrete production were monitored. Seventy and 85% boiler efficiencies were assumed to calculate BTUH boiler outputs.

IV. HEAT PUMP

The N.D.C.P. plant requires a 2.7 million BTUH peak output of steam. Upon consultation with heat pump manufacturers, a cascade system combining two standard units was specified. A cascade system is necessary because a conventional heat pump is not capable of producing steam from 97°F source water. In a cascade system, the condenser of the first heat pump is tied to the evaporator of the second heat pump. This system will then take water at 97°F and produce steam - 220°F. (See Diagram B).

The heat pump system would be designed so that if it is desired to use less than 100% capacity, refrigerant flow can be regulated to limit output to as low as 500,000 BTUH.

We examined the performance characteristics of the specified heat pump system at two geothermal water flow rates (290 GPM and 145 GPM) through the evaporator of the first machine in the cascade system. The respective coefficients of performance (COP) were 5.5, and 4.5 with 97°F source water. The second machine would have a COP of approximately 3.7 with 130-140°F fluid passing through its evaporator in a closed loop with the condenser of the first machine. The overall performance and electric input requirements of the system are itemized in Tables 4-7.

The four existing boilers would be replaced by one cascade system. A distribution system to carry the steam from the heat pumps to the curing locations would have to be constructed. It would also be necessary to build a housing around the heat pumps, which would involve a 15' x 30' addition to the Pipe Plant Building. The estimated cost of this addition, excluding electrical and plumbing, would be \$6,000 to \$7,000.

The existing oil fired boilers would be left in place for stand-by purposes. If off peak power or interruptable service were employed to receive a more competitive electrical rate the existing boilers could be used more often.

Approximately 700 feet of insulated underground pipe to carry steam from the heat pumps to the pre-stress plant would cost approximately \$8,000 including excavation and installation. Roughly 200 feet of insulated steel pipe would be necessary in the pipe plant to distribute steam to the wet cast and kiln boilers at an installed cost of \$2,000.

The sizing of plumbing and more importantly pumps, has an effect on both the capital costs and operating costs of this equipment. At a geothermal water flow of 300 GPM, 330 kw is required to operate the heat pumps and 53 kw of energy is necessary for the well pumps. If the flow is reduced to 150 GPM, the heat pump electrical input increases to 370 kw while pumping costs decrease to 11 kw. The capital cost of the heat pumps remains at \$140,000 at either flow rate. The cost of the well pumps, however, varies from \$4,000 at the 150 GPM flow rate to \$11,000 at the 300 GPM flow rate.

The capital cost of the equipment and operating costs are itemized in Table 8 at the two flow rates. Because the total energy consumption is very similar at both flow rates and the initial cost of pumps is lower at the 150 GPM flow rate the lower flow rate will be used for economic comparison purposes.

V. ECONOMIC ANALYSIS

The economic analysis of this study addresses fuel costs with existing boilers, electricity costs, capital investment, amortization of equipment, maintenance cost, inflation factors, and tax incentives.

The total 1980 consumption of fuel, for curing purposes, was 79,000 gallons. Approximately 42,000 gallons were used in the pre-stress plant boiler and 37,000 gallons were used in the kiln and wet-cast boilers.

From this information the total annual hours of operation for the pre-stress boiler was calculated at 7,000 compared to 1,700 hours on the other boilers. This large differential was accounted for by some serious problems experienced in the pre-stress operation in 1980 necessitating up to three times the normal curing time. Those problems have since been alleviated so that presently the pre-stress plant operates roughly double the hours that the wet cast boiler and kiln boilers operate. Therefore in the economic analysis, the total hours of operation was based on 1,700 hours at full capacity and 1,700 hours at the 500,000 BTUH output level. The geothermal water flow rate will remain the same at both BTUH output levels. The performance of the heat pumps will remain relatively constant.

Present N.D.C.P. fuel cost of \$1.20 per gallon was used.

Electricity costs are based on present rates charged by the utility serving the N.D.C.P. facility. A utility representative expressed interest in an off-peak schedule or remote interruptable service for a heat pump system. This could eliminate the \$5/kw demand charge and reduce the charge from \$.033/kwh to \$.028. A cost analysis comparing this rate - assuming 10% usage of existing boilers is made. An inflation

factor of 15% is annually used for electricity.

Capital equipment costs were calculated from quotes from area suppliers and contractors. The costs include installation, material, engineering and contractor overhead and profit. The life expectancy of the equipment is twenty years on most of the equipment.

Additional operating costs on the heat pump system should be minimal, approximately \$1,000 per year. The cost of maintaining the system is expected to be somewhat higher than the existing boiler system - estimated at \$3,000 annually.

Additional benefits available to N.D.C.P. Company are the State & Federal tax incentives. A 10% investment tax credit is allowable on all of the capital investment in a geothermal project similar to the one studied here. Also 15% State and 15% Federal tax credits for alternate energy applications such as these are possible.

If we assume a total of 40% tax credits reducing the capital investment by \$200,000 and if the \$300,000 balance was financed at 12% interest, amortized for 10 years, with an annual payment of \$30,000 principal plus interest accrued, the accumulated net benefit would become positive in year seven. This assumes a 10% overall inflation rate, 13% annual electric rate increases and an annual inflation factor of 15% on oil prices. (See Tables 9 & 10)

It should be noted however that these assumptions are best case conditions. Presently interest rates are near 20% and it may be some time before financing costs are as low as 12%. The off-peak electrical rate is not guaranteed as the plant may not be able to operate within the utilities guidelines to qualify for the rate reduction. Inflation factors are difficult to predict in the present unsteady economy so the factors used may be

unrealistic. The cost of energy may or may not inflate at a higher rate than the overall inflation factor as assumed.

Also tax benefits are dependent on the tax liability of the North Dakota Concrete Products Company and because tax laws are constantly changing, TPI does not consider this benefit as a highly reliable economic justification. If any one of the above factors reduced the benefits significantly the pay-back period would be likewise extended.

VI. CONCLUSIONS & RECOMMENDATIONS

The geothermal alternative examined in this study by TPI has lead to the following conclusions for the North Dakota Concrete Products Company:

1. The operating cost savings of the geothermal system over the operating costs of the existing oil-fired system is insufficient to provide an acceptable rate of return on the investment at today's cost of money.
2. Our study did not disclose any enterprise, or nearby housing development which could utilize the geothermal waste water to help improve the economic viability of this project.
3. As the cost of energy continues to rise at a rate above the overall rate of inflation, the economics of this project could be re-examined.

VII. APPENDIX

DIAGRAM A

NORTH DAKOTA CONCRETE PRODUCTS COMPANY PLANT LAYOUT

DIAGRAM B
PIPING DIAGRAM OF GEOTHERMAL HEAT
RECOVERY SYSTEM - HEAT PUMP CASCADE SYSTEM

North Dakota State Department of Health

Public Health Laboratory

Chemical Analysis of Water

Los number: 81- 4825

County: Burleigh

ND CONCRETE PRODUCTS
601 BISMARCK AVE
BISMARCK, ND 58501

Date Received: 8/13/81
Date Reported: 8/25/81

Township: 139N Range: 78W Section: W1/2

Source: 300' WELL, FOX HILLS FORMATION

Comment: CC:ROGER FALKENSTEIN TPI 1200 MISSOURI AVE

Analysis			
pH	8.0		
Conductivity	3880.	umhos/cm	
Total Dissolved Solids	2170	ms/l	High
Iron	0.17	ms/l	Satisfactory
Manganese	0.020	ms/l	Satisfactory
Calcium	10.0	ms/l	
Magnesium	3.50	ms/l	
Total Hardness (as CaCO3)	39.	ms/l	Low
Potassium	5.75	ms/l	
Sodium	888.	ms/l	Very high
Chloride	800.	ms/l	Very high
Sulfate	3.	ms/l	Low
Total Alkalinity (CaCO3)	775.	ms/l	High
Bicarbonate (HCO3)	947.	ms/l	
Carbonate (CO3)	0.	ms/l	
Fluoride	0.5	ms/l	
Percent Sodium	97.9	%	
Turbidity	0.00	FTU	
Sodium Adsorption Ratio	61.5		
Nitrate as N	< 2	ms/l	Satisfactory
Total Hardness	2.28	Grains/gallon	Low

This water would be usable, but not desirable for a domestic supply.

This water is classified C4-S4 for irrigation.
Contact your county agent for more information.

This water may prove harmful to individuals on salt-free diets. Please consult your family doctor.

Statement: This analysis includes chemical content only, and does not determine the bacterial quality of the water.

For any further information, write to:
The State Department of Health, Bismarck, ND 58505.

Per.

Chemist

TABLE 1
EXISTING FUEL BOILER DATA

Parameter	Wet Cast	Kilns	Pre-Stress	Total
Fuel Consumption (Gal/Hour)	13.0	9.0	5.3	27.3
Water Consumption (Gal/Hour)	173	94	55	322.0
BTUH Output	1,200	1,000	500	2,700
Boiler Efficiency	.70	.85	.70	.76
*Fuel Cost/Hr.	\$15.60	\$10.80	\$6.36	\$32.76
Annual Hours of Operation	1,700	1,700	3,400	
Annual Cost	\$26,520	\$18,360	\$21,624	\$66,504
Annual Hours of Operation With Off Peak	170	170	340	
Annual Cost	\$2,652	\$1,836	\$2,162	\$6,650

*Assumes fuel cost of \$1.20/gal.

TABLE 2

WELL INFORMATION

Flow Rate	150 GPM	300 GPM
Supply Well		
Size	8"	8"
Depth	3,100'	3,100'
Head	50'	150'
Pump Type	Submersible	Submersible
Pump Size	5.0 H.P.	15.0 H.P.
Pumping Electrical Input	3.7 kw	11.2 kw
*Pumping Cost/Hr.	\$.27	\$.77
*Pumping Cost - Annual	\$911	\$2,601
Reinjection Well		
Size	5"	5"
Depth	3,100'	3,100'
Head	150'	300'
Pump Type	Centrifugal	Centrifugal
Pump Size	10.0 H.P.	40.0 H.P.
Pump Electrical Input	7.5 kw	29.9 kw
Pumping Cost/Hr.	\$.51	\$2.04
Pumping Cost Annual	\$1,722	\$6,944

*Assumes present electric rate of \$.033/kwh plus \$5/kw monthly demand charge and 3,400 hours of operation annually.

TABLE 3

WELL INFORMATION

Flow Rate	150 GPM	300 GPM
Supply Well		
Size	8"	8"
Depth	3,100'	3,100'
Head	50'	150'
Pump Type	Submersible	Submersible
Pump Size	5.0 H.P.	15.0 H.P.
Pumping Electrical Input	3.7 kw	11.2 kw
*Pumping Cost/Hr.	\$.10	\$.31
*Pumping Cost - Annual	\$352	\$1,066
Reinjection Well		
Size	5"	5"
Depth	3,100'	3,100'
Head	150'	300'
Pump Type	Centrifugal	Centrifugal
Pump Size	10.0 H.P.	40.0 H.P.
Pump Electrical Input	7.5 kw	29.9 kw
Pumping Cost/Hr.	\$.21	\$.84
Pumping Cost Annual	\$714	\$2,846

*Assumes electric rate of \$.028/kwh and 3,400 hours of operation annually.

TABLE 4

HEAT PUMP DATA

Geothermal Flow Rate	300 GPM	150 GPM
BTUH Output (BTUH)	2.7×10^6	2.7×10^6
Source Water Temperature	97°F	97°F
Leaving Water Temperature	87°F	77°F
Output Temperature (Steam)	220°F	220°F
Heat Pump #1		
C.O.P.	5.5	4.5
Electrical Input (kw)	133	163
*Electrical Cost/Hr.	\$9.09	\$11.19
*Electric Cost - Annual	\$15,441	\$19,014
Heat Pump #2		
C.O.P.	3.7	3.7
Electrical Input (kw)	195	195
Electrical Cost/Hr.	\$13.32	\$13.32
Electrical Cost - Annual	\$22,640	\$22,640
Overall System		
C.O.P.	2.24	2.05
Electrical Input (kw)	328	258
Electrical Cost/Hr.	\$22.41	\$24.51
Electrical Cost - Annual	\$38,081	\$41,654

*Assumes 1,700 hours of operation annually and an electric rate of \$.033/kwh plus \$5.00 per kw demand per month.

TABLE 5

HEAT PUMP DATA

Geothermal Flow Rate	300 GPM	150 GPM
BTUH Output (BTUH)	500,000	500,000
Source Water Temperature	97°F	97°F
Leaving Water Temperature	95°F	93°F
Output Temperature (Steam)	220°F	220°F
Heat Pump #1		
C.O.P.	5.5	4.5
Electrical Input (kw)	24.6	30.2
*Electrical Cost/Hr.	\$.81	\$1.00
*Electric Cost - Annual	\$1,380	\$1,694
Heat Pump #2		
C.O.P.	3.7	3.7
Electrical Input (kw)	36.1	36.1
Electrical Cost/Hr.	\$1.19	\$1.19
Electrical Cost - Annual	\$2,025	\$2,025
Overall System		
C.O.P.	2.24	2.05
Electrical Input (kw)	60.7	66.3
Electrical Cost/Hr.	\$22.41	\$1.19
Electrical Cost - Annual	\$3,405	\$3,719

*Assumes 1,700 hours of operation annually and an electric rate of \$.033/kwh. Demand charge is included in the cost in Table 4.

TABLE 6

HEAT PUMP DATA

Geothermal Flow Rate	300 GPM	150 GPM
BTUH Output (BTUH)	2.7×10^6	2.7×10^6
Source Water Temperature	97°F	97°F
Leaving Water Temperature	87°F	77°F
Output Temperature (Steam)	220°F	220°F
Heat Pump #1		
C.O.P.	5.5	4.5
Electrical Input (kw)	133	163
*Electrical Cost/Hr.	\$3.72	\$4.56
*Electric Cost - Annual	\$6,331	\$7,759
Heat Pump #2		
C.O.P.	3.7	3.7
Electrical Input (kw)	195	195
Electrical Cost/Hr.	\$5.46	\$5.46
Electrical Cost - Annual	\$9,282	\$9,282
Overall System		
C.O.P.	2.24	2.05
Electrical Input (kw)	328	258
Electrical Cost/Hr.	\$9.18	\$10.02
Electrical Cost - Annual	\$15,613	\$17,041

*Assumes 1,700 hours of operation annually and an electric rate of \$.028/kwh - which is a discounted rate for off-peak usage.

TABLE 7

HEAT PUMP DATA

Geothermal Flow Rate	300 GPM	150 GPM
BTUH Output (BTUH)	500,000	500,000
Source Water Temperature	97°F	97°F
Leaving Water Temperature	95°F	93°F
Output Temperature (Steam)	220°F	220°F
Heat Pump #1		
C.O.P.	5.5	4.5
Electrical Input (kw)	24.6	30.2
*Electrical Cost/Hr.	\$.69	\$.85
*Electric Cost - Annual	\$1,171	\$1,438
Heat Pump #2		
C.O.P.	3.7	3.7
Electrical Input (kw)	36.1	36.1
Electrical Cost/Hr.	\$1.01	\$1.01
Electrical Cost - Annual	\$1,718	\$1,718
Overall System		
C.O.P.	2.24	2.05
Electrical Input (kw)	60.7	66.3
Electrical Cost/Hr.	\$1.70	\$1.86
Electrical Cost - Annual	\$2,889	\$3,146

*Assumes 1,700 hours of operation annually and an electric rate of \$.028/kwh which is a discounted rate for off-peak usage.

TABLE 8

CAPITAL COST OF THE EQUIPMENT
(Includes Material & Installation, Contractor O & P)

Geothermal Flow Rate	150 GPM	300 GPM
Heat Pump Cascade System	\$170,000	\$170,000
Steam Distribution Lines	10,000	10,000
Heat Pump Housing	7,000	7,000
Wells		
8" Supply	200,000	200,000
5" Reinjection	100,000	100,000
Pumps		
Supply	2,000	3,000
Reinjection	<u>2,000</u>	<u>8,000</u>
Subtotals	\$491,000	\$498,000
Engineering Costs	<u>5,000</u>	<u>5,000</u>
Total	\$496,000	\$503,000

TABLE 9

OVERALL COST/BENEFIT ANALYSIS

- Existing Electric Rate -

<u>Parameter</u>	<u>Annual Operating Cost</u>
Geothermal	
Heat Pump Energy	\$45,373
Well Pump Energy	1,722
Extra Maintenance	3,000
Extra Operating Costs	<u>1,000</u>
Subtotal	\$51,095
Present System	
Fuel Cost	\$66,504
Annual Benefit (Present System Cost Less Geothermal Costs)	\$15,409

- Discounted Off-Peak Rate -

Geothermal	
Heat Pump Energy	\$20,547
Well Pump Energy	714
Extra Maintenance	3,000
Extra Operating	1,000
Stand-by-fuel	<u>6,650</u>
Subtotal	\$31,911
Present System	
Fuel Cost	\$66,504
Annual Benefit - (Present System Cost Less Geothermal Costs)	\$34,593

TABLE 10

* 10 YEAR COST/BENEFIT ANALYSIS OF GEOTHERMAL SYSTEM

Year	Annual Operating Costs		Savings		Capital Cost		Benefit	
	Present	Geothermal	Annual	Cummulative	Annual	Cumulative	Annual	Cumulative
1	66,504	31,911	34,593	34,593	66,000	66,000	\$-31,407	\$-31,407
2	76,480	36,073	40,407	75,000	62,400	128,400	-21,993	-53,400
3	87,952	40,783	47,169	122,169	58,800	187,200	-11,631	-65,031
4	101,144	46,115	54,989	177,158	55,200	242,400	- 221	-65,242
5	116,316	52,152	64,164	241,322	51,600	294,000	12,564	-52,678
6	133,763	58,990	74,773	316,055	48,000	342,000	26,773	-25,945
7	153,828	66,732	87,096	403,151	44,400	386,400	42,696	16,751
8	176,902	75,503	101,399	504,550	40,800	426,800	60,599	77,350
9	203,437	85,438	117,999	622,549	37,200	464,000	80,799	158,149
10	233,953	96,695	137,258	759,807	33,600	497,600	103,658	262,207

* Assumes an overall inflation rate of 10%, a 13% inflation factor for electric rates, a 15% inflation factor for fuel oil and a 12% interest charge on a \$300,000 investment.

REFERENCES

Temptrol Corporation, Rapid City, South Dakota

Schwab - Volhaber, Inc., St. Paul, Minnesota

LTP Enterprises, Fargo, North Dakota

Russel Driling, Harvey, North Dakota

North Dakota Dept. of Health, Division of Water Supply and
Pollution Control, Bismarck, North Dakota

G.P.M., Inc., Bismarck, North Dakota

Northwest Pipe, Inc., Mandan, North Dakota

H.A. Thompson & Sons, Plumbing & Heating, Inc., Bismarck,
North Dakota

A.W.B.W. Architects & Engineers, Bismarck, North Dakota

Capital Electric Cooperative, Bismarck, North Dakota

North Dakota Geothermal Office, Bismarck, North Dakota