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SAN BERNARDINO VALLEY COLLEGE
Geothermal Potential for Heating & Cooling
San Bernardino, California

July 1981

Prepared by:

TMAD ENGINEERS, INC.

Prepared for:

GEO-HEAT CENTER ✓
Oregon Institute of Technology
Klamath Falls, Oregon 97601

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July 5, 1981

GEOTHERMAL POTENTIAL FOR
HEATING AND COOLING FACILITIES
SAN BERNARDINO VALLEY COLLEGE,
SAN BERNARDINO, CALIFORNIA

✓
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ABSTRACT

The potential for converting to geothermal heating at the campus of San Bernardino Valley College is considered. Also considered is the possibility of using well water for water cooled condensor cooling of air conditioning equipment. To provide water supply a production well, water distribution system and an injection well would be installed for each system.

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I. THE EXISTING SYSTEM AND ITS USAGE

The existing heating system includes a combined total of 17 hot water heating boilers at a total of 11 locations throughout the campus. These boilers supply process hot water to heating coils in air handling units. The air handling units are used in conjunction with a variety of different types of systems ranging from double duct, multi-zone, remote air handlers and large capacity single zone systems. The Physical Science and Life Science Buildings are currently served by boilers in the North Hall and Chemistry Building boilers respectively. Virtually all boilers are "Bryan" dual fuel boilers. Similar boilers are also used to perform the physical education related operations of shower and pool water heating. One building, the Planetarium, is heated by electric resistance heating coils.

The campus air conditioning is performed by 11 direct expansion water cooled liquid chillers at 8 different locations. Most of these chillers are high capacity (100-200 ton range) Trane centrifugal Centra-Vac units with Baltimore Air Coil cooling towers. These units supply chilled water to the same systems described with the heating system. The total tonnage of chillers on the proposed system is approximately 1300 tons. A few buildings would probably not be included in the scope of the proposed project due to site location or non-conductive system types. These are the Technical Building, Art and Medical Arts Buildings.

In this preliminary stage it is unimportant what the breakdown of the consumption is from building to building. During design this would be estimated for purposes of pipe and connection sizing. Table No. 1 separates, based on square footage, the approximate consumption of what would be on the proposed systems and what would not.

TABLE NO. 1

Current Total Campus Electric Load	8,612,384 KWH
Current Total Campus Natural Gas Load	410,315 Therm
Load of Buildings on Proposed System (Electric)	6,958,201 KWH
Load of Buildings On Proposed System (Gas)	352,360 Therm
Load of Air Conditioning On Proposed System (Electric)	3,131,190 KWH ¹
Load on Proposed System (Gas)	334,742 Therm ²

1. Based on forty-five percent of the load being used for air conditioning system.
2. Based on ninety-five percent of the load being used for space and pool heating systems.

II. THE COOLING SYSTEM WITH GROUNDWATER

Introduction

The method of using ground water for water cooling of condensers is not new. It has been used often in the past, especially in areas with consistently high wet bulb temperatures or high water tables. The water is taken from a relatively shallow water table aquifer, pumped up and through the condensers of the air conditioning system and is then re-injected or exhausted by some other method.

Description of Cycle

A multi-stage deep well jet pumping system with a 24" well casing and a 16" pump bowl would be employed to supply 3500 GPM of water, raising it from a depth of approximately 50 feet. This water would be delivered through a 12" water main to the first point of connection. From this point on the size of the supply main would be reduced and a return main would be employed to receive the condensor discharge water. Prior to supplying the system the water would probably be treated chemically for removal of any particulate matter or scale-causing agent. This may not be necessary as chemical analysis of the Mt. Vernon and Mill well water shows an extremely clean product (Table No. 2).

TABLE NO. 2

	<u>Well #66</u>	<u>Well #12</u>
Sodium	112	29
Potassium, mg/l	1.2	3.6
Calcium, mg/l	5	48
Magnesium, mg/l	2.4	12.6
Silica, mg/l	27	23
Indicated Reservoir		
<u>Na-K-Ca</u> (Fournier & Truesdell, 1974)	116	206
<u>Mg. Correction</u> (Fournier & Potter, 1978)	90	127
<u>Silica</u> (Fournier & Rowe, 1968)	80	69

Supply branches would carry the water through a coil in the outside fresh air intake to pre-cool that air and on to points of connection in the existing condensor water supply system. This connection would be performed with a three-way valve so that the existing cooling towers could be used during low campus load or system down time.

A secondary relatively small circulating pump would be used in the main to vary capacity and equalize the supply pressure between stages of the well pump. All supply piping below grade would be uninsulated plastic or transite. See Figure 1 for cycle diagram and 2 for connection locations.

GROUND WATER COOLING CYCLE DIAGRAM

FIGURE NO. 1

Mt. Vernon Ave.

College Dr.

LEGEND

- PIPING
- CONNECTION
- → + CONN. POINT TO ALL (4) LINES

SAN BERNARDINO VALLEY COLLEGE

scale: 1":200'

CAMPUS PIPING LAYOUT

FIGURE NO. 2

Potential Costs and Savings

Costs

The probable initial costs would be as shown in Table 3.

TABLE NO. 3 - CONDENSOR WATER SYSTEM COST

50' Well with Pumps	\$40,000
Equipment Yard	5,000
11 Condensor Connections w/3 Way Valves	44,000
Water Treatment	8,000
Injection Well	25,000
Fresh Air Coils w/ Controls	50,000
4400 Feet of Piping w/ Cut & Patch	<u>57,000</u>
Construction Subtotal	229,000
Profit & Overhead	<u>57,000</u>
Construction Total	286,000
Design & Engineering	<u>29,000</u>
Total Project Cost	\$315,000

Savings

The assumptions with which the potential savings are predicted are:

- That 3500 GPM of 70°F water is available at no deeper than 50'.
- The 150 HP pumping system operates 25% unloaded 2,000 hours per year.
- 15% of the existing air conditioning usage is consumed by the condensor pumps and tower fans.
- The remaining 85% of the load will operate 15% more efficiently with fresh air pre-cooling and with 70°F water in place of the 80-85°F water currently supplied from the cooling tower.

Based on these assumptions and the consumption shown in Table No. 1, the savings would be 645,105 KW per year. The Life Cycle Costs are analyzed in the economics section of this report.

III. THE HEATING SYSTEM WITH GEOTHERMAL

Introduction

The San Bernardino area appears to be particularly conducive to the use of geothermal energy. Tests and well samples describe a very clean, high temperature source at a reasonably shallow depth. (See Figure 3 for Mill and Mount Vernon temperature graph.) This indicates that the use of this water for heating services is a viable alternative to conventional sources.

Description of Cycle

With the 900 foot depth required for the heating system a vertical line shaft turbine would be used to supply the high capacity and high head necessary. This pump would also be multi-stage with a secondary, relatively small, circulating pump that would be used in the main to vary capacity and equalize the supply pressure between stages of the well pump. The pumping elements would be submerged in a 14 inch well casing with a 10 inch pump bowl. A 6" bond strand or similar high temperature insulated piping product would act as supply main to the first connection. This size would be reduced as a return main is connected. The possibility of chemical treatment is similar to that described in the cooling section.

Branches from the supply main would be connected to the existing heating coils. The consistent temperature of supply water would determine whether secondary 2-row coils in addition to the existing 2-row coils would be necessary. The additional coil area would

be necessary if a required temperature drop of greater than 40°F or an inlet temperature of less than 190°F is encountered. From the coil the water would be discharged to the return line.

The swimming pool heating system does not require as high a process water temperature to satisfy its use. With proper heat exchange surface the return water at approximately 140°F could be used to heat the pool, requiring less water to be pumped to the system. Domestic water use is fairly limited except for shower consumption in the locker rooms. The heating of shower water could also be accomplished by use of return water low temperature heat content. See Figure 4 for cycle diagram.

Potential Costs & Savings

Costs

The probable initial costs would be as shown in Table 4.

TABLE NO. 4 GEOTHERMAL HEATING COSTS

900 Ft. Well W/ Pumps	\$70,000
Equipment Yard	\$5,000
Hot Water Connections W/ New Coils	\$60,000
Water Treatment	\$11,000
Injection Well	\$35,000
5600 Ft. of Insulated Piping W/ Cut & Patch	<u>\$112,000</u>
Construction Sub-Total	\$293,000
Profit & Overhead	<u>\$73,000</u>
Construction Total	\$366,000
Design & Engineering	<u>\$37,000</u>
Total Project Cost	\$403,000

GEOHERMAL HEATING CYCLE DIAGRAM

FIGURE NO. 4

Savings

The assumptions with which the potential savings are predicted are:

- That 700 GPM of 190°F water is available at no deeper than 900'..
- The 250 HP pump will operate annually at the rate necessary to fulfill previous campus heating requirements.

Based on these assumptions and the consumption shown in Table No. 1, the savings would be 334,742 therms. The pumping power consumption would be 579,797 KW. The Life Cycle Costs are analyzed in the economics section of this report.

IV. LIFE CYCLE COST ANALYSIS
FOR
HEATING AND COOLING FACILITIES
SAN BERNARDINO VALLEY COLLEGE
SAN BERNARDINO, CALIFORNIA

Life cycle cost analysis for the conceptual geothermal heating and cooling systems at San Bernardino Valley College, San Bernardino, California appears in tables 5 and 6.

It was assumed that the system would come on line in 1982. The twenty year forecasts assume a 7% economic inflation rate over the project life, and additional inflation rates for conventional fuels as forecast by the Oregon Department of Energy "Fifth Annual Report" as follows:

Natural Gas

9.0% through 1984
9.2% 1985 through 1989
10.0% 1990 through 1994
10.2% 1995 through 2001

Electrical Power

7.9% through 1987
9.1% through 2001

In tables five and six:

Column one forecasts the twenty year cost of natural gas based on current consumption of the heating system presented in table five.

Column one forecasts the twenty year cost of electricity based on current consumption of the cooling system presented in table six.

The remaining columns in these two tables present information common to both systems as follows:

Column two provides the twenty year forecast for electricity to run the proposed system.

Column three is a projection of the maintenance costs for the proposed system inflating at the economic inflation rate.

Column four projects the insurance costs for the proposed system, inflating at 2% per annum.

Column five lists the financing costs assuming a 10% twenty year bond is issued to finance 100% of each system. Note that only interest payments are made on the principle with the bond maturing in twenty years, causing the large balloon payment in the twentieth year.

Column six presents the twenty year net cash flow resulting from the conversion to the proposed system.

Column seven is a discounted cash flow of column six to arrive at a net present value of the proposed systems over the conventional systems.

The geothermal heating system is more attractive than the ground water cooling system, providing a simple payback of seven years and a discounted payback of ten years. This compares to a simple payback of ten years and a discounted payback of sixteen years for the ground water cooling system. Notice that the above payback periods are not exactly accurate because of the balloon payment that occurs in the twentieth year when the bond matures.

The inflation rates used are ultra conservative. If real rates of inflation prove to be higher than those used in this report the projects will be much more economically feasible than indicated in tables five and six. There is also a high probability that with deregulation, natural gas prices will increase significantly in the very near future. This would have a considerable effect on the economics of the geothermal heating system. For instance, the year zero price of natural gas was assumed to be \$0.3808 per therm. Increasing this price by only \$0.20 per therm causes the simple payback to drop to three years and one month.

The ground water cooling system uses a considerable amount of electrical power to displace the electricity presently being consumed. The ratio is about 1.26 : 1 in favor of the ground water system. Therefore if the rate of inflation for electricity proves to be higher than that forecast in this report, the effect will not be as noticeable on the economic feasibility of this system.

Table 5

LIFE CYCLE COST ANALYSIS
FOR
SAN BERNARDINO VALLEY COLLEGE
HEATING

Date: Jan. 15, 1982

COST OF CAPITAL 10%
TOTAL CAPITAL COST 403000
NET PRESENT VALUE 1136449

	1	2	3	4	5	6	7	
	NATURAL GAS CURRENT SYSTEM	ELECTRICITY GEOTHERMAL SYSTEM	MAINTENANCE GEOTHERMAL SYSTEM	INSURANCE GEOTHERMAL SYSTEM	FINANCING 10% BOND	NET ENERGY SAVINGS	DISCOUNTED CASH FLOW 10%	
PRESENT COST	127470	42209	10110	2015				
YEAR								YEAR NUMBER
1982	138942	45527	10818	2055	40300	42297	38452	1
1983	151447	49105	11575	2096	40300	50467	41708	2
1984	165077	52965	12385	2138	40300	59427	44648	3
1985	180264	57128	13252	2181	40300	69584	47527	4
1986	196848	61618	14180	2225	40300	80750	50140	5
1987	214958	66461	15172	2269	40300	93025	52510	6
1988	234735	72509	16234	2315	40300	105691	54236	7
1989	256330	79108	17371	2361	40300	119552	55772	8
1990	281963	86307	18587	2408	40300	136770	58004	9
1991	310160	94161	19888	2456	40300	155811	60072	10
1992	341176	102729	21280	2505	40300	176866	61991	11
1993	375293	112077	22770	2556	40300	200146	63773	12
1994	412822	122277	24364	2607	40300	225882	65430	13
1995	454930	133404	26069	2659	40300	255158	67191	14
1996	501333	145543	27894	2712	40300	287596	68848	15
1997	552469	158788	29846	2766	40300	323535	70411	16
1998	608821	173238	31936	2821	40300	363348	71886	17
1999	670921	189002	34171	2878	40300	407447	73283	18
2000	739355	206201	36563	2935	40300	456290	74607	19
2001	814769	224966	39123	2994	443300	107381	15961	20
TOTAL	7602613	2233114	443477	49938	1209000	3717022	1136449	

SIMPLE PAYBACK
DISCOUNTED PAYBACK

7 YEARS
9 YEARS

Table 6

LIFE CYCLE COST ANALYSIS
FOR
SAN BERNARDINO VALLEY COLLEGE
COOLING

Date: Jan. 15, 1982

COST OF CAPITAL 10%
TOTAL CAPITAL COST 315000
NET PRESENT VALUE 406834

	1 ELECTRICITY CURRENT SYSTEM	2 ELECTRICITY GROUND WATER SYSTEM	3 MAINTENANCE GROUND WATER SYSTEM	4 INSURANCE GROUND WATER SYSTEM	5 FINANCING 10% BOND	6 NET ENERGY SAVINGS	7 DISCOUNTED CASH FLOW 10%	
PRESENT COST	227951	180987	6015	1575				
YEAR								YEAR NUMBER
1982	245868	195213	6436	1607	31500	12719	11563	1
1983	265193	210556	6887	1639	31500	16250	13430	2
1984	286037	227106	7369	1671	31500	20062	15073	3
1985	308519	244957	7884	1705	31500	24178	16514	4
1986	332769	264210	8436	1739	31500	28623	17772	5
1987	358925	284977	9027	1774	31500	33421	18865	6
1988	391587	310910	9659	1809	31500	39518	20279	7
1989	427221	339203	10335	1845	31500	46184	21545	8
1990	466098	370070	11058	1882	31500	53470	22676	9
1991	508513	403747	11832	1920	31500	61434	23686	10
1992	554788	440488	12661	1958	31500	70140	24584	11
1993	605274	480572	13547	1997	31500	79655	25380	12
1994	660354	524304	14495	2037	31500	90054	26086	13
1995	720446	572016	15510	2078	31500	101420	26707	14
1996	786006	624069	16596	2120	31500	113842	27253	15
1997	857533	680859	17757	2162	31500	127416	27730	16
1998	935568	742817	19000	2205	31500	142251	28144	17
1999	1020705	810414	20330	2249	31500	158461	28501	18
2000	1113589	884162	21753	2294	31500	176174	28806	19
2001	1214926	964620	23276	2340	346500	-119470	-17759	20
TOTAL		9575268	263849	39034	945000	1275802	406834	

SIMPLE PAYBACK
DISCOUNTED PAYBACK

10 YEARS
16 YEARS

V. CONCLUSIONS

The approach of this report in analyzing the potential of the applications discussed is consistently conservative. Water treatment is calculated as a cost, however, if preliminary findings regarding water quality are accurate, elimination of these systems will result in a savings. During design an alternative method of discharging water such as a lake or storm drainage system may result in a considerable savings in initial and term costs. A substantial maintenance factor with gradient increase is included in the present worth of the system when actually a savings may result over the use of the existing multiple boiler system, and no consideration is given to reduction of electric consumption in Planetarium resistance heating system.

Even with the intentional consistently conservative nature of this analysis, the potential for savings is evident. It is apparent that if the assumptions made appear reasonable, further investigation and probable implementation of the systems described is an economically feasible and logical approach to greatly reducing the San Bernardino Valley College energy consumption.

APPENDIX

STATE OF CALIFORNIA
CALIFORNIA ENERGY COMMISSION
ENERGY AUDIT FORM

ORGANIZATION NAME
SAN BERNARDINO VALLEY COLLEGE
BUILDING NAME
N/A

ELECTRICITY USAGE RECAP
(NEW 5/79)

ACCOUNT OR METER NO.	SCH NO.	PRI NO.	✓ IF PRO	KWH	COST	MAX KW
PC-714-002777	DW-8	N/A	✓	8177040	335973.43	
PC-714-003320	GS-2	N/A		338910	12577.62	
B-413757	GS-1	N/A		19154	1267.37	
3CEP-134613	GS-2	N/A		55120	396.65	
CEP-113160	GS-1	N/A		0	53.41	
709-004869	GS-2	N/A		22160	1624.22	
TOTAL ALL METERS-12 MO. PERIOD ENDING	MO. 12	YEAR 79		2612364	354716.75	

TOTAL

ENERGY PRORATE WORKSHEET

ORGANIZATION NAME	SAN BERNARDINO VALLEY COLLEGE
BUILDING NAME	N/A

☒ ELECTRICITY* ☐ NATURAL GAS TYPE

[illegible]

THE HIGHEST DEMAND OF

KW'S

END (EE: 3/80)

"TA REW"

ORGANIZATION NAME
SAN BERNARDINO VALLEY COLLEGE
BUILDING NAME

TOTAL
'79

50 FT

1933106 ANT - 15984
1933107 FISH - 51767
25318 MEDICAL - 7,379
49

ENERGY PRORATE WORKSHEET

ORGANIZATION NAME	SAN BERNARDINO VALLEY COLLEGE
BUILDING NAME	N/A

TYPE
ELECTRICITY* ☒ NATURAL GAS

[illegible]

THE HIGHEST DEMAND OF _____ KW'S
OCCURRED IN THE MONTH OF _____

COOLING CALC'S

$$\text{CONDENSER GPM} = 3 \text{ GPM/TON} \times 1200 \text{ TONS} = 3500 \text{ GPM}$$

$$\text{HP} = \frac{(3500) (125' \text{ HD})}{3960 (.75 (\eta))} \approx 150 \text{ HP}$$

EXIST. ELEC LOAD

$$[8612384, -351,932 - 1139781 - 162,470] \times .95$$

$$= 3,131,190 \text{ KW/YR}$$

PUMP CONSUMPTION (25% UNLOADED)

$$\frac{(.75) (150 \text{ HP}) (.746 \text{ KW/HP})}{(.75) (\eta)} \times 2000 \text{ HRS/YR} = 223,800 \text{ KW/H}$$

SAVINGS W/ PUMP CONSIDERED

$$(368,905) - (223,800) = 645,105 \text{ KW/YR}$$

HEATING CALCS

CONSUMPTION

$$(410,315 - 30,297 - 9859 - 17,799) = 352,360 \text{ THERMS}$$

GPM

$$\frac{352,360,000 \text{ BTU}}{20,000 \text{ BTU/GPM}} \times \frac{1}{2500 \text{ HR/YR}} \approx 700 \text{ GPM}$$

HEAD

$$T.H. = 2800/100 \times 3 + 900 = 984 \text{ FT}$$

HP

$$\frac{(700)(984)}{(3960)(.75)} = 231$$

THIS IS NOT ADEQUATE FOR PEAK LOAD HOWEVER
IN THAT MUCH OF THE LOAD IS SWIMMING POOL
WHICH CAN BE HEATED BY RETURN WATER FOR
MORE ΔT A 250 HP WILL BE OK

USAGE

$$\frac{[700 \text{ GPM} \times 2500 \text{ HR/YR}](984)(.746)}{3960(.15)} = 579,797 \text{ KW/YR}$$