DOE/ET/27256--T36

DE82 015134

INDIAN SPRINGS SCHOOL,
BIG BEND, CALIFORNIA

January 1982

NOTICE
PORTIONS OF THIS REPORT ARE ILLEGIBLE.
It has been reproduced from the best
available copy to permit the broadest
possible availability.

Prepared by:

GEO-HEAT CENTER
OREGON INSTITUTE OF TECHNOLOGY
Klamath Falls, Oregon
97601

DISCLAIMER

This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

DISCLAIMER

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, expressed or implied, or assumes any legal responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately-owned rights.

INDIAN SPRINGS SCHOOL
BIG BEND, CALIFORNIA

INTRODUCTION

The Indian Springs School is located in Big Bend, California. The building, which was constructed in three phases beginning in the early 1950's, is heated entirely by electric resistance unitary equipment. In addition, a swimming pool is also heated with an electrical resistance device. The construction is characterized by large glass areas (single glaze) and relatively low insulation levels. Together, these facts result in substantial costs for electrical demand and consumption.

Two hot springs are located in the Big Bend area exhibiting temperatures of 136 and 180°F. In addition to the springs, the domestic water well at the school produces 72°F water.

As a result of their high utility costs and the local geothermal manifestations, the school has requested that a study be performed regarding the feasibility of geothermal use at Indian Springs School.

In the course of this study, it was determined that the mechanical systems at the school currently have little control. It is strongly recommended that the school investigate the possibility of having an energy audit performed. This should be done prior to the consideration of any alternative heating system.

SUMMARY OF CONCLUSIONS

This study examined primarily a ground water heat pump system for the school, based on the available 72°F water at the site. Such a system would result in a capital cost of \$101,200 and a discounted payback (12%) of 14 years. The net savings generated in the first year would amount to 168,876 kwh/year or \$12,780 per year based on

the current electrical rate of \$0.0757 per kwh. This first year savings decreases to \$10,434 per year when increased maintenance and insurance costs are considered.

In addition to the heat pump system, a duct heat exchanger type system was considered. In view of the lack of geological information however, cost estimates did not consider production well or disposal methods. Instead, additional figures were generated which indicate the amount of capital which would be available for resource development at the end of each year. Results of this analysis are shown in Table 2. Heat pump system results are shown in Table 1.

The savings figures for both systems reflect a substantial reduction in electrical usage which should result from the installation of the swimming pool cover. Installed in November of 1981, the cover has not been in place long enough to indicate these savings on electrical bills. However, based upon heat loss calculations performed for this study, the cover could potentially result in a savings in annual electrical consumption of approximately 32%.

Several additional areas of potential energy savings are also pointed out in the text of the report.

AVAILABILITY OF GEOTHERMAL

There are two springs located in the area of Indian Springs School. Hunt Hot Spring, located across the river, produces water at 136°F. Big Bend Hot Spring, located about 1.5 miles from the school, produces water at 180°F. Unfortunately, conversations with California Division of Mines and Geology personnel indicate that little is known of the

geology in the Big Bend area. As a result, no prediction can be made as to the probability of intercepting a hot water strata at the school site. However, it is expected that some geological work will be done in the Big Bend area during the summer of 1982. It is strongly advised that school officials contact the Division of Mines and Geology and make arrangements for a site visit at the school.

EXISTING SYSTEM

The school is heated entirely with electric resistance equipment. Figure 1 shows the location and capacity of existing systems. Classroom, office, gymnasium and pool areas are heated with forced air type equipment. Corridors and entrance areas are heated with natural convection equipment. An electric boiler supplies hot water to finned duct coils serving the locker room and pool area. The boiler also supplies hot water to a heat exchanger in the hot water storage tank. Pool water is heated via a 40 kw in line unit in the filter room. A small 30 gallon domestic hot water heater is located in the electric service room near the principal's office with a 50 gallon unit in the kitchen. Current installed capacity of this system is as follows:

Space heating	331.55 kw
Pool heating	40.00 kw
Domestic hot water	33.00 kw

ENERGY BALANCE

In order to determine the required capacity of a new system and evaluate the existing systems, a block heat loss analysis was performed on the buildings. Details of these calculations can be found in the

appendix.

Evaluation of the building heat loss was complicated by the lack of available information regarding construction details. Some assumptions were made regarding insulation levels and ventilation rates and should be verified prior to final design. The following figures summarize the peak heat losses and annual energy consumption for the major building loads.

	<u>Peak (Btu/hr)</u>	<u>Annual (kwh/yr)</u>
Space heating	505,000	220,372
Pool	93,800	181,438
Pool building - ventilation		
Locker room	54,432	32,735
Pool	184,313	92,577
Domestic hot water	100,000	7,029

The heating loads were based upon an inside temperature of 68°F and an outside design temperature of 10°F. Annual consumption was completed using the ASHRAE degree day method. The degree day method does not allow for thermostat set back. However, it is our understanding that the temperature set back mechanism at the school is not currently operational.

Domestic hot water energy consumption was based upon ASHRAE guidelines as set forth in the 1978 Systems Volume.

Pool heat loss was based upon 80° water temperature and 80° air temperature. In November of 1981 a cover was installed on the swimming pool. The cover should substantially reduce power consumption for pool heating. This factor has been taken into consideration in the calculations of energy savings.

ENERGY SAVING POTENTIAL

During the calculation of heating loads, a number of areas of potential energy savings were identified. It is beyond the scope of this report to quantify the savings to be derived from each of these areas, however, each of the areas should be evaluated prior to the design of any heat pump based system. It is possible also that the economic attractiveness of some of the following items could exceed that of the proposed system. Major issues which should be addressed in an energy study are as follows:

1. Building set back control systems are currently inoperative and most equipment is manually controlled. This mode results in inefficient operations. Existing control systems should be reconnected and tested.
2. The classroom areas are characterized by large expanses of north facing glass areas. These glass areas contribute somewhat to natural lighting, however, they contribute substantially to space heat loss (53% of design load). The glass areas should be reduced by installing insulated panels over the openings. The new fluorescent lighting system should be able to accommodate the reduction in natural lighting with an overall energy savings.
3. The south facing corridor is almost entirely composed of glass. Although heat gain during sunny periods is high, nighttime loss reduces the net energy attractiveness of this area. The local solar characteristics should be evaluated to determine whether or not the glass in this area should be covered with insulated panels.

4. Entrance ways are composed of a single set of doors in all locations. Vestibules attached to these entrances would reduce infiltration of cold outside air and thus reduce heating loads.
5. Ventilation rates of the classroom unit ventilators is unknown. These rates should be evaluated and brought into line with code requirements (5 cfm/person). In most cases, ventilation rates in such equipment far exceeds the minimum.
6. The ventilation controls for the pool and locker room appear to be inoperative. Based on the consumption of electricity, these systems are constantly supplying outside air to the pool and locker room. Since the pool is only used about four hours per week (and the cover is in place the balance of the time), there is no need to supply outside air to remove moisture. The relative size of the consumption for heating this outside air is shown in the figures under the "Energy Balance" section as Pre-heat. A lack of dampers in the three pool exhaust fans may be aggravating this problem.
7. The position of the heating units in the gym tends to cause heated air to migrate to the roof area where it does not effectively contribute to heating the occupied area. The installation of Casablanca type fans in the peak area could help in driving this heated air back down to lower levels.

GEOHERMAL SYSTEM

In view of the type of existing heating system at the school, and in order to accommodate a geothermal system, all new terminal equip-

ment would have to be installed. For purposes of this study, this new system was assumed to be a two pipe fan coil type. Another option would be a central air handler/duct distribution type system. However, since there is no attic space in which to install ductwork (and as a result, it would have to be installed on the roof), the piping system was felt to be less costly as a retrofit. Figure 2 shows the layout of the proposed system and equipment capacities. These capacities are based on the calculated losses found in the appendix. Figure 3 is a flow scheme for the heat pump system. This study concentrated on the heat pump based system, however, the retrofit for the direct/heat exchanger system would be essentially the same. If warmer water than 140°F should be encountered at a production well, somewhat smaller unit heaters would be employed. This would not, however, have a large affect upon system capital cost.

All areas of the main school building currently served by electric resistance units would be retrofitted with hot water unit heaters. These units would be supplied with hot water through insulated steel supply and return lines. For purposes of cost estimates, these lines were assumed to be installed exposed on existing wells.

The locker room would continue to be heated by finned direct coils as before. However, the coils themselves would be replaced with larger surface area coils. The existing water valves and circulating pump would be employed.

The heating for the pool building would employ the same air delivery system. However, the finned coil now supplying only preheat energy would be replaced with one capable of supplying the entire heating

duty for the structure. This coil would also use the same control valve and circulating pump on the existing unit. In addition, ventilation would be provided to those areas only during occupied periods thus reducing energy consumption caused by unnecessarily heating cold outside air.

Pool water would be heated by a new heat exchanger to be installed in parallel with the existing unit. Duty of this heat exchanger would be 140,000 Btu/hour. This is comparable to the existing 40 kw electric unit's capacity.

Domestic hot water would be heated by a new heat exchanger connected to the existing storage tank. This design would be employed at the storage tanks serving the locker rooms and kitchen. The domestic hot water heater serving the bathrooms would remain unchanged. In view of the low temperature water employed (140°F), storage temperature would only be maintained at about 120° maximum.

The heat pumps (or heat exchanger) would be installed in a new enclosure outside the existing mechanical room. Piping from the enclosure would enter the mechanical room where it would be distributed to the four zones: main building space heat; pool and locker room space heat; domestic hot water; and pool water heating. The pool water and main building zones would require new circulating pumps.

In order to minimize the peak capacity requirement of the heat pump, the pool water heat zone would be shut down during periods of pool use (in cold weather). This would allow extra capacity to be diverted for heating of ventilation air during these periods. This would not effect pool temperature. Assuming an 80°F air and water

temperature, heat loss from the pool in terms of temperature drop would only amount a fraction of a degree even if uncovered for several hours.

Total heat pump capacity for the proposed system is 925,000 Btu/hr. In order to accomplish this duty, the heat pump would remove approximately 660,714 Btu/hr from a stream of 72°F water produced by the production well. The cooled water (57°F) would then be disposed of at the injection well. The heat removed from the water in addition to the energy input of the compressor would be rejected at the condensor in the form of 140°F water for heating purposes. Based on the performance of the "Westinghouse Templifier", heat pump model TPB-055, two units would be required to accomplish this task at a COP (coefficient of performance) of 3.2. This means that for the required capacity of 925,000 Btu/hr, the heat pump supplied the heat using only $1/3.2$ (or 29%) as much electricity as the present system.

In order to supply the 88 gpm of water required by the heat pump, some modifications to the existing well will be necessary. At a minimum, this would require a larger pump and possibly some deepening of the well. In addition, some means of disposal will have to be provided for this flow. For purposes of this study, this disposal method was assumed to be an injection well located 400 feet from the production well. Figure 3 shows the basic flow scheme for this system.

A cost estimate was also made for a heat exchanger type system, assuming a successful hot water well could be brought in at the school. This system would be essentially the same as the heat pump system in terms of heating equipment and retrofit. The major difference would be

that the heat pumps would be replaced with a plate heat exchanger.
The capital costs for this system do not include production well or disposal of the geothermal source.

Figure 1 - EXISTING HEATING EQUIPMENT, INDIAN SPRINGS SCHOOL

Key

1	-	15 kw
2	-	4.5 kw
3	-	3 kw
4	-	11.25 kw
5	-	3.75 kw
6	-	4.4 kw HW coil
7	-	4.4 kw HW coil
8	-	16 kw HW coil
9	-	29.3 kw domestic hot water heater
10	-	54 kw HW coil
11	-	150 kw boiler supplies 6-10
12	-	92.4 kw total (31 strip heaters)

Figure 2 - HEAT PUMP SYSTEM RETROFIT EQUIPMENT, INDIAN SPRINGS SCHOOL

Key

1	-	40,000
2	-	43,000
3	-	20,000
4	-	22,000
5	-	13,500
6	-	6,000
7	-	30,000
8	-	54,000
9	-	100,000
10	-	315,063
11	-	140,000
12	-	925,000

FIGURE 1

WZ 2-4-82

FIGURE 2

101-24-02

FIGURE 3 FLOW SCHEME FOR HEAT PUMP SYSTEM
INDIAN SPRINGS SCHOOL

144-2-4-92

LIFE CYCLE COST ANALYSIS
FOR
THE INDIAN SPRINGS SCHOOL, BIG BEND, CALIFORNIA

Life cycle cost analysis for the conceptual geothermal heating system at the Indian Springs School in Big Bend, California, appears in tables one and two.

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:

Electrical Power

7.86% through 1987

9.10% through 2001

In tables one and two:

Column one provides the twenty year cost of electricity for heating the school.

Column two projects the electrical power costs for the geothermal heat pump system.

Column three forecasts the maintenance costs for the geothermal system inflating at 7% per annum.

Column four projects the insurance costs for the geothermal system.

Column five assumes 100% equity financing and shows the twenty year interest payment that would be required for a 12% bond maturing in 20 years.

Column six shows the twenty year cash flows after all costs of the geothermal system are subtracted from projected costs of the present heating system.

Column seven discounts the cash flows from column six to arrive at a net present value for these cash flows.

Column eight provides a running total of the discounted cash flows appearing in column seven. This is particularly significant in evaluating table two. Since table two does not include the capital costs of drilling a deeper well, by analysing the difference between the capital investment of \$65,000 and the cumulative cash flow in column eight, we can evaluate the amount the school could afford to spend for resource development and the effect it would have on the payback of the project. This evaluation appears in column nine.

INDIAN SPRINGS SCHOOL

COSTS-HEAT PUMP SYSTEM

Capital Costs

Well improvement and new pump	-	2,500
Injection well	-	4,000
Heat pumps	-	47,000
Enclosure	-	2,500
Piping	-	18,200
Controls	-	1,200
New circulating pumps	-	1,700
Hot water coils	-	3,800
Unit heaters	-	4,100
Heat exchangers (water to water)	-	<u>3,200</u>
		SUBTOTAL
		88,200
	15 % contingency	<u>13,000</u>
	TOTAL	101,200

Operating Costs

	\$/Yr
Increased electricity	7,673
Maintenance	1,827
Insurance	469

Savings

20,453

INDIAN SPRINGS SCHOOL

COSTS-HEAT PUMP SYSTEM

Capital Costs

Well improvement and new pump	-	2,500
Injection well	-	4,000
Heat pumps	-	47,000
Enclosure	-	2,500
Piping	-	18,200
Controls	-	1,200
New circulating pumps	-	1,700
Hot water coils	-	3,800
Unit heaters	-	4,100
Heat exchangers (water to water)	-	<u>3,200</u>
SUBTOTAL		88,200
15 % contingency		<u>13,000</u>
TOTAL		101,200

Operating Costs

	\$/Yr
Increased electricity	7,673
Maintenance	1,827
Insurance	469

Savings

20,453

INDIAN SPRINGS SCHOOL
COSTS-HEAT EXCHANGER SYSTEM

Capital Costs

Heat exchanger	-	4,000
Enclosure	-	2,500
Piping	-	27,800
Controls	-	2,400
New circulating pumps	-	1,700
Hot water coils	-	3,800
Unit heaters	-	4,100
Heat exchangers	-	3,200
Production pump	-	<u>8,000</u>

SUBTOTAL 56,500

15% contingency 8,500

TOTAL 65,000

Operating Costs

Increased electrical use	1,278
Maintenance	476
Insurance	310

Savings 20,453

Table 1

LIFE CYCLE COST ANALYSIS
FOR
INDIAN SPRINGS SCHOOL
BIG BEND, CALIFORNIA

Date: Feb. 3, 1982

COST OF CAPITAL 12%
TOTAL CAPITAL COST 101200
NET PRESENT VALUE 56582

	1	2	3	4	5	6	7	8	
	ELECTRICITY CURRENT SYSTEM	ELECTRICITY GEOTHERMAL SYSTEM	MAINTENANCE GEOTHERMAL SYSTEM	INSURANCE GEOTHERMAL SYSTEM	DEBT SERVICE FOR 12% BOND FINANCING	NET ENERGY SAVINGS	DISCOUNTED CASH FLOW 12%	CUMULATIVE DISCOUNTED CASH FLOW	YEAR
PRESENT COST	20453	7673	1827	469					
YEAR									
1982	22061	8276	1955	478	12144	-793	-708	-708	1
1983	23795	8927	2092	488	12144	144	115	-593	2
1984	25665	9628	2238	498	12144	1157	823	231	3
1985	27682	10385	2395	508	12144	2251	1430	1661	4
1986	29858	11201	2562	518	12144	3432	1948	3608	5
1987	32205	12082	2742	528	12144	4709	2386	5994	6
1988	35135	13181	2934	539	12144	6338	2867	8861	7
1989	38333	14381	3139	550	12144	8119	3279	12140	8
1990	41821	15689	3359	560	12144	10068	3631	15771	9
1991	45627	17117	3594	572	12144	12200	3928	19699	10
1992	49779	18675	3846	583	12144	14531	4177	23877	11
1993	54309	20374	4115	595	12144	17081	4384	28261	12
1994	59251	22228	4403	607	12144	19869	4553	32814	13
1995	64642	24251	4711	619	12144	22918	4689	37504	14
1996	70525	26458	5041	631	12144	26251	4796	42300	15
1997	76943	28865	5394	644	12144	29896	4877	47176	16
1998	83944	31492	5771	657	12144	33881	4935	52111	17
1999	91583	34358	6175	670	12144	38237	4972	57083	18
2000	99917	37484	6607	683	12144	42998	4992	62076	19
2001	109010	40895	7070	697	113344	-52996	-5494	56582	20
TOTAL	1082083	405946	80142	11623		240292	56582		

SIMPLE PAYBACK
DISCOUNTED PAYBACK

14 YEARS
0 YEARS

Date: Feb. 3, 1982

Date: Feb. 3, 1982

ITAL	12%
AL COST	65000
VALUE	204160

YEAR

5 YEARS
6 YEARS

APPENDIX

INDIAN SPRINGS SCHOOL

DEGREE DAY INFORMATION:

	78	79	80	81
OCT	248	241	331	
NOV	699	695	601	
DEC	954	825	789	
JAN		929	824	747
FEB		742	552	632
MAR		504	660	636
APR		445	339	325
MAY			752	183

ELECTRICAL USE:

LIGHTING

3 CLASS ROOMS - 3 ROW 7 FIXTURE 2 TUBE 40W

$$3 \cdot 7 \cdot 2 \cdot 40 = 1680 \text{ W.} \quad (1.86 \text{ W/FT}^2)$$

$$3 \cdot 1680 = 5040 \text{ W.}$$

OFFICE -	7 \cdot 2 \cdot 40 =	560 W
STOCK RM -		100 W
MACH. RM -		100 W
ENTRANCE -	5 \cdot 2 \cdot 40 =	400
CORRIDOR -	7 \cdot 2 \cdot 40 =	560
GYM -	10 \cdot 2 \cdot 40 =	800
BOILER RM -		200
BOYS RM -		80
GIRLS RM -		160
MUSIC -		160
KITCHEN -		200
		<hr/>
		10040 W
		10.04 KW

ASSUME 9 HRS/DAY 23 DAYS/MO

$$9 \cdot 10.04 \cdot 23 = 2078 \text{ kWh/MO} \times 1.15 = \underline{\underline{2390}}$$

MOTORS ETC.

REFRIGERATOR ASSUME 2 TP

$$2 \cdot 746 = 1.48 \text{ KW}$$

$$1.48 \cdot 25 \cdot 720 = 266.4$$

KIDNEY CUP PUMPS

$$.75 \text{ TP} + .5 \text{ TP}$$

WATER MOTORS 3.0 TP + .5 TP

$$\text{TOTAL} = 4.75 \text{ TP}$$

$$4.75 \cdot .746 = 3.54 \text{ IP}$$

$$3.54 \cdot 720 =$$

2521 kWh

$$\text{POOL CIRCULATING PUMP} \\ 2 \text{ IP} \cdot .746 \cdot 720 =$$

1066 kWh

TOTAL

6243

DOMESTIC HOT WATER

$$23 \cdot 1 \text{ gal/st.} \cdot 8.33 \cdot (140-50) \cdot 40 \\ = 202 \text{ kWh/m}$$

SHOWERS ASSUME 8 SHOWER HEADS
@ 15 MIN ES. @ 2.75 gpm ea TIME/HR.

$$\frac{1}{3413} \cdot 8 \cdot 15 \cdot 2 \cdot 2.75 \cdot 4 \cdot 8.33 \cdot (140-50) = 579 \text{ kWh/m}$$

781

POOL HEATING:

WATER TEMPERATURE 80°F
COVER INSTALLED LAST NOV.
ASSUME 80°F EW 80°F E 50°F CH
75' x 25'

$$Q_D = 17454 \text{ BTU/HR}$$

$$Q_R = 0$$

$$Q_E = 87091 \text{ BTU/HR (7 mph)}$$

$$Q_{CV} = 0$$

TOTAL

$$Q_E (\text{ASHRAE}) \text{ FROM P. 5} \\ 97.5 \text{ #/HR}$$

$$97.5 \cdot 1000 \text{ BTU/#} = 97,500 \text{ BTU/HR}$$

USE LOWER VALUE OF 87,091 BTU/HR

W/COVER

$$17,454 \cdot 720 \div 3413 =$$

3682

W/O COVER

$$(17454 + 87091) \cdot 720 \div 3413 \\ = 22054 \text{ kWh/m}$$

CURRENT INSTALLED CAPACITY:

$$3 \text{ CLASSROOMS @ } 11.25 \text{ kW} = 33,750 \text{ BTU/HK} \\ (115,189 \text{ BTU/HK TOTAL})$$

$$\text{CORRIDOR 3 UNITS @ } 3.75 \text{ kW EA} = 11,250 \text{ BTU/HK} \\ (33,750 \text{ BTU/HK})$$

$$\text{ENTRANCE 2 UNITS @ } 4.5 \text{ kW EA} = 9,000 \text{ BTU/HK} \\ (30,117 \text{ BTU/HK})$$

$$\text{BATHROOMS 2 UNITS @ } 3.0 \text{ kW EA} = 6,000 \text{ BTU/HK} \\ (20,478 \text{ BTU/HK})$$

$$\text{OFFICE 2 UNITS @ } 3.0 \text{ kW EA} = 6,000 \text{ BTU/HK} \\ (20,478 \text{ BTU/HK})$$

KITCHEN - DISCONNECTED

$$\text{GPA 5 UNITS @ } 15 \text{ kW EA} = 75,000 \text{ BTU/HK} \\ (255,975 \text{ BTU/HK})$$

LOOKBOOKS

RE-HEAT:

BASED ON ASHRAE MINIMUM OF 30 cfm/person
20 persons/1000 ft²

$$\Delta \text{LEA} = 24 \times 24 = 576 \div 1000 = .576 \\ .576 \cdot 20 = 11.52 \approx 12 \text{ persons}$$

$$12 \cdot 30 = 360 \text{ cfm OA.}$$

$$360 \cdot 1.08 \cdot 70 = 27,216 \text{ BTU/HK} \\ (54,432 \text{ BTU/HK})$$

RE HEAT:

$$\text{ASSUME } 15,000 \text{ BTU/HK EA} \\ (30,000 \text{ BTU/HK})$$

POOL AREA:

AIR SYSTEM - P

AIR FLOW REQUIRED
FROM ASHRAE

DESIGN 80° AIR 82° WATER 60° CH

$$\rho = .50683 \text{ psia} \cdot 2.036 = 1.032 \text{ in. hg}$$

$$\rho = \frac{DP = 65' \text{ F } \rho @ 65' : 3056}{3056 \cdot 2.036} = .6222 \text{ in. hg.}$$

$$\begin{aligned}
 W_p &= G \Delta (r_{pw} - r_a) \\
 &= .10 \cdot (25.75) (1.032 - .6222) \\
 &= 76.8 \text{ #/hr}
 \end{aligned}$$

$$\begin{aligned}
 Q &= 76.8 \div [.075 (.012 - .0062)] \\
 &= 146,285 \text{ cfh} \div 60 \\
 &= 2438 \text{ fpm}
 \end{aligned}$$

$$\begin{aligned}
 2438 \cdot 1.03 \cdot 70 &= (184313 \text{ Btu/hr}) \\
 184313 \div 3413 &= 54.0
 \end{aligned}$$

Strip heaters in pool tank:

$$11.8400 = (92400 \text{ kw} - 315084 \text{ Btu/hr})$$

$$\text{Pool heater } 40 \text{ kw} = (136520 \text{ Btu/hr})$$

TOTAL HEATING REQUIREMENT

$$1,177,336 \text{ Btu/hr}$$

Actual Building Load

Assume 10°/68° 1 unit/hr

K-1 wall, L-5 roof, R-5 insul slab, single glass

Classroom 3

$$\text{FLOOR} - 40 \cdot 60$$

$$= 2400 \text{ Btu/hr}$$

$$\text{WALLS} - 360 \cdot .091 \cdot 58$$

$$= 1900$$

$$\text{GLASS} - 300 \cdot 1.13 \cdot 58$$

$$= 19662$$

$$\text{CEILING} - 950 \cdot .20 \cdot 58$$

$$= 11020$$

$$\text{INFIL} - 900 \cdot 10 \div 60 = 1.08 \cdot 58$$

$$= 9396$$

$$44,378 \text{ Btu/hr}$$

Classroom 2

$$42,794$$

$$42,794$$

COLLIDOL

$$\text{FLOOR} - 98 \cdot 40$$

$$= 3920$$

$$\text{WALLS} - 200 \cdot .25 \cdot 58$$

$$= 2900$$

$$\text{GLASS} - 360 \cdot 1.13 \cdot 58$$

$$= 23,594$$

$$\text{ROOF} - 720 \cdot .20 \cdot 58$$

$$= 8352$$

$$\text{INFIL} - 96 \cdot 1.08 \cdot 58$$

$$= 6013$$

$$44,779$$

USE LEADING
DESIGN WS.
1.05/68

10°/68°

Assume air
10' cfm
NORTH WALL
= 80% (p.)

SUBTRACT 3009
9 = WALL

BOY'S RM

WALL - 110 . 091 . 58
 ROOF - 168 . 20 . 58
 GLASS - 8 . 1.13 . 58
 INFIL - 224 . 1.08 . 58
 FLOOR - 26 . 40

= 580
 = 1949
 = 524
 = 1403
 = 1040
 5496

GIRLS RM

5496

OFFICE

FLOOR - 16 . 40
 ROOF - 512 . 20 . 58
 GLASS - 160 . 1.13 . 58
 INFIL - 53 . 1.08 . 58
 WALL - —

= 640
 = 5939
 = 10208
 = 3319

20107

ENTRANCE

FLOOR 20 . 40
 ROOF 720 . 20 . 58
 GLASS 240 . 1.13 . 58
 INFIL 40 . 1.08 . 58

= 320
 = 8352
 = 15729
 = 2506

27387

GYM

ROOF - 4960 . 20 . 58
 WALLS - 3780 . 091 . 58
 INFIL - 506 . 1.08 . 58
 GLASS - 100 . 1.13 . 58
 FLOOR - —

= 52896
 = 14950
 = 21696
 = 6554

111096

POOL BUILDING

ROOF - 4080 . 09 . 58
 WALLS - 1336 . 09 . 58
 GLASS - 680 . 1.13 . 58
 INFIL - 316 . 1.08 . 58
 FLOOR - 170 . 40

= 21298
 = 6974
 = 44567
 = 51114
 = 6800

130753

LOCKER ROOMS

50,000

TOTAL

2052000

LOCKER ROOM PRE HEAT
 POOL DECK

PREDICTED ANNUAL ELEC USE w/o pool cover

- LIGHTING AND MOTORS:		kwh/yr
LIGHTS	9m · 2390 kwh/m =	21510
REFRIG.	266 · 12 =	3192
MOTORS	6243 · 9 =	56187 (42440)
- DOMESTIC HOT WATER	781 kwh/mo 9m	7029
- SPACE HEATING:		
	$\frac{505,080 \text{ BTU/HK} \cdot 5000 \cdot 24}{58 \cdot 3413 \cdot 1.0} \cdot 79$	220372
- VENTILATION		
LOCKER ROOMS	$\frac{54,000 \cdot 5000 \cdot 24}{58 \cdot 3413 \cdot 1.0}$	= 32735
	$\frac{\text{POOL AREA } 184313 \cdot 5000 \cdot 24}{70 \cdot 3413 \cdot 1.0}$	= 92577
- POOL	$94254 \cdot 6570 \div 3413$	= 181438
TOTAL		601,293
Avg Actual Usage		\$17,000

POOL USE w/ COVER

$$17454 \cdot 6570 \div 3413 = 33598 \text{ kwh/yr}$$

— SAVINGS FOR HEAT EXCHANGER SYSTEM :

$$\begin{array}{lcl} \text{DHW} & 7029 \cdot .75 & = 5272 \text{ kWh/yr} \\ \text{SPACE HT} & 220372 & = 220372 \end{array}$$

Assume VENT
ON ONLY 5%
OF TIME

VENTILATION

LOUVER MASS

$$32735 \cdot .05 = 1637$$

POOL DECK

$$92577 \cdot .05 = 4629$$

POOL

$$17454 \cdot .0570 \div 3413 = 30884$$

$$.05 \cdot 76500 \cdot .0570 \div 3413 = 7363$$

$$\underline{270157 \text{ kWh/yr}}$$

W/COVER
SAVINGS

— SAVINGS DUE TO POOL COVER :

REDUCED POOL WATER HEAT -

$$\text{PEAK } 94,454 - 17,454 = 79,000 \text{ Btu/hr}$$

$$\text{ANNUAL } 181,438 - (30884 + 7363) = 143,191 \text{ kWh/yr}$$

REDUCED VENTILATION.

PEAK - NO CHANGE

$$\text{ANNUAL} - 92,577 - 4629 = \underline{87,948}$$

$$\text{TOTAL } 231,139 \text{ kWh/yr}$$

$$\text{AVG ANNUAL BEFORE COVER} - 617,274 \text{ kWh/yr}$$

$$231,139 \div 617,274 = \underline{37.4\%}$$

— SAVINGS DUE TO HEAT PUMP SYSTEM:

$$\text{SAME AS HT-x SYSTEM} - 270157$$

INCREASED CONSUMPTION FOR PUMPS (ASSUME FAN POWER SAME)

WELL PUMP - 88 gpm

OLD S.W. 165'

$$\text{NEW } (165/65) \cdot 88 = 223'$$

$$40 \text{ psi DISCH.} = 92'$$

$$\text{T.D.H.} = 315'$$

$$\text{HP} = 88 \cdot 8.33 \cdot 315 \div 33,000 = 7.00 \text{ HP}$$

$$\text{WIRE TO WATER } 50\% \quad 60\% \quad 7.00 \div .6 = 11.7 \text{ IP}$$

$$11.7 \text{ IP} \cdot 1629 \text{ hrs/yr} \cdot .746 = \underline{14,189 \text{ kWh/yr}}$$

INJECTION PUMP

~~55~~ ϕ μ $\text{m} \approx 90' \text{ HD}$

$$88 \cdot 8.33 \cdot 30 \div 33,000 \cdot .55 = 1.2 \text{ IP}$$

$$1.2 \cdot .746 \cdot 1629 = \underline{1472 \text{ kWh/yr}}$$

CIRCULATING PUMPS $2 \times \frac{1}{2} \text{ IP's}$

$$1 \cdot .746 \cdot 1629 = \underline{1226 \text{ kWh/yr}}$$

$$\text{TOTAL FOR HEV PUMPS} \quad \underline{16851 \text{ kWh/yr}}$$

HEAT PUMP ENERGY CONSUMPTION (COMPRESSION)
COP - 3.2 (NET INPUT USE)

$$270,157 \text{ kWh/yr} \div 3.2 = 84,424 \text{ kWh/yr}$$

TOTAL ELECTRICAL CONSUMPTION FOR HT-PUMP SYSTEM

$$84,424 + 16827 = 101,311 \text{ kWh/yr}$$

$$\text{NET SAVINGS} = 270,157 - 101,311 = 168,876 \text{ kWh/yr}$$

VALUE @ .075 \$/kWh

$$.075 \cdot 168,876 \text{ kWh/yr} = 12,666 \text{ \$/yr}$$

HT-X SYSTEM -

PUMP ENERGY SAME AS HT PUMP SYSTEM.

$$- 16827 \text{ kWh/yr}$$

NET SAVINGS

$$270,187 - 16827 = 253,300 \text{ kWh/yr}$$

VALUE @ .075 \$/kWh

$$253,300 \cdot .075 = 18,997 \text{ kWh/yr}$$