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Foley

PRELIMINARY EVALUATION OF GEOTHERMAL SPACE HEATING AT VANDENBURG AFB

1. Sell HQ Sac on initial phase.

INTRODUCTION

A geothermal heating system for Vandenburg AFB was scoped which can significantly reduce the present use of natural gas. This geothermal heating system will reduce heating costs, conserve natural gas and reduce emissions to the atmosphere. The geology of the Base indicates a plentiful supply of hot geothermal fluid.

SUMMARY

A geothermal district heating system for Vandenburg AFB is economically feasible. Engineering-economic analysis assumed a 158°F geothermal source, requiring a peak flow of 3,420 gpm that can be located near the main building heat loads. Injection wells are located one mile from the production wells. With proper reinjection of the geothermal fluid, it is estimated that the heating life cycle can be significantly increased beyond the 20 year period used for this analysis.

Total project cost, including all retrofit, is $26,200,000, conservatively, and $21,900,000, optimistically. Yearly operating and maintenance expense totalled $1,165,115, conservatively, and $907,882, optimistically. Simple and discounted payback periods for the geothermal heating system is shown as follows:

Optimistic:	5.25 years simple payback
	6.18 years discounted (7%) payback
Conservative:	6.21 years simple payback
	8.13 years discounted (7%) payback

Presently 680 x 10^9 Btu per year is used annually at Vandenburg AFB to space heat approximately 9 x 10^6 square feet of buildings and supply hot water for domestic use. Total energy saved during the 20 year life of the project is about an equivalent 136 million therms of natural gas.

Tables I and II show a breakdown for the geothermal capital and yearly expenses both for the optimistic and conservative cases studied.

TABLE I

Vandenburg AFB Geothermal Capital Costs - Preliminary

(158° F Geothermal Fluid)

Capital Expense	Optimistic	Conservative
Resource Exploration & Identification	$ 271,500	$ 271,500
Wellfield Development:		
Production Wells	1,231,200	3,078,000
Injection Wells	615,600	1,539,000
Wellhead Equipment & Controls	646,720	1,079,440
Collection & Reinjection Piping	1,000,880	1,183,040
Production & Reinjection Well Pumps	442,320	852,720
Pump Installation	132,696	255,816
Subtotal Wellfield Development	$ 4,069,416	$7,988,016
Equipment:		
Heat Pump System & Controls	$ 1,560,000	$1,560,000
Geo-Fluid Filters	256,500	256,500
Surge Tanks, Supply & Reinjection	417,483	417,483
Heat Exchangers	221,378	221,378
Distribution System Recirculation Pumps	36,000	36,000
Equipment Installation	747,408	747,408
Subtotal Equipment	$ 3,238,769	$3,238,769
Facilities Piping & Controls:		
End Use Distribution Piping & Insulation	$ 6,372,549	$6,372,549
End Use Equipment Retrofit	3,285,000	$3,285,000
Subtotal Facilities Piping & Controls	$ 9,657,549	$9,657,549
Project Costs:		
Facility	$ 75,000	$ 75,000
Contractor Mark-up & Construction Management	1,945,700	1,945,700
Design	650,000	650,000
Subtotal Project Costs	$ 2,670,700	$2,607,700
Contingency	1,990,793	2,382,653
Total Capital Expense	$21,898,727	$26,209,187

TABLE II

Vandenburg AFB Geothermal Operations & Maintenance - Preliminary

(158°F Geothermal Fluid)

Yearly Expense	Optimistic	Conservative
Operating Expenses:		
Electricity ($.065 per kWh)		
Heat Pump Compressor	$ 241,182	$ 241,182
Recirculation System Pumps	15,240	17,460
Production Well Pumps	89,992	89,992
Reinjection Well Pumps	62,200	62,200
Natural Gas for Peaking ($.420 per Therm)	171,524	171,524
Total Operating Expenses	$ 580,138	$ 582,358
Maintenance Expenses:		
Pumps (production, reinjection, recirculation)	$ 20,520	$ 41,040
Geo-fluid Filters	5,130	5,130
Heat Pumps, System Piping & Controls	46,800	46,800
Collection/Reinjection Field Piping & Controls	20,017	23,660
Heat Exchangers	4,427	4,427
Production/Reinjection Wells	230,850	461,700
Total Maintenance Expenses	$ 327,744	$ 582,757
Total Yearly Cost	$ 907,882	$1,165,115

Year Expenses, Presently:

Natural Gas	$ 2,858,755
Equipment Maintenance (estimated)	714,688
	$ 3,573,443

SYSTEM HEATING REQUIREMENTS

Of the 680 x 10^9 Btu per year presently used at Vandenburg AFB for space and hot water heating, a conversion efficiency .8 was assumed for conversion of the fossil fuel to thermal energy. The proposed geothermal/heat pump system has a conversion efficiency of near 1.0 and supplies approximately 94% of the annual heating or base load requirement. The remaining 6% of the annual heating which occurs during a very short time during the winter heating period is supplied by conventional fuels. This design minimizes heating system cost and conserves fossil fuels. Figure 1 is a schematic diagram of the proposed base load geothermal/heat pump system.

Between 3.42 and 6.84 production wells were calculated to produce the necessary total of 3,420 gpm of 158°F geothermal water to satisfy system peak heating requirements. The heat pump increases the distribution system supply temperature to 165°F with 4,640 kW of electrical power at peak demand. As the thermal load decreases to the point where a supply temperature of 137°F will satisfy the thermal load demand, the heat pumps will shut off allowing only the geothermal system to function.

Plant equipment was costed on the basis of the fractional number of wells calculated. In practice, the system size would be determined on the nearest number of whole wells which satisfy base loading requirements at peak thermal load.

DESCRIPTION OF SYSTEM

The geothermal wellfield supply/reinjection and heat pump control systems operate in conjunction with thermal loads through surge tanks at production and injection wells. A turbine pump with variable speed drive is installed in each production well. As load demand is changed, the variable speed drives are adjusted in unison. The variable speed driver minimizes electrical power usage and increases pump lifetime.

Geothermal Heating System

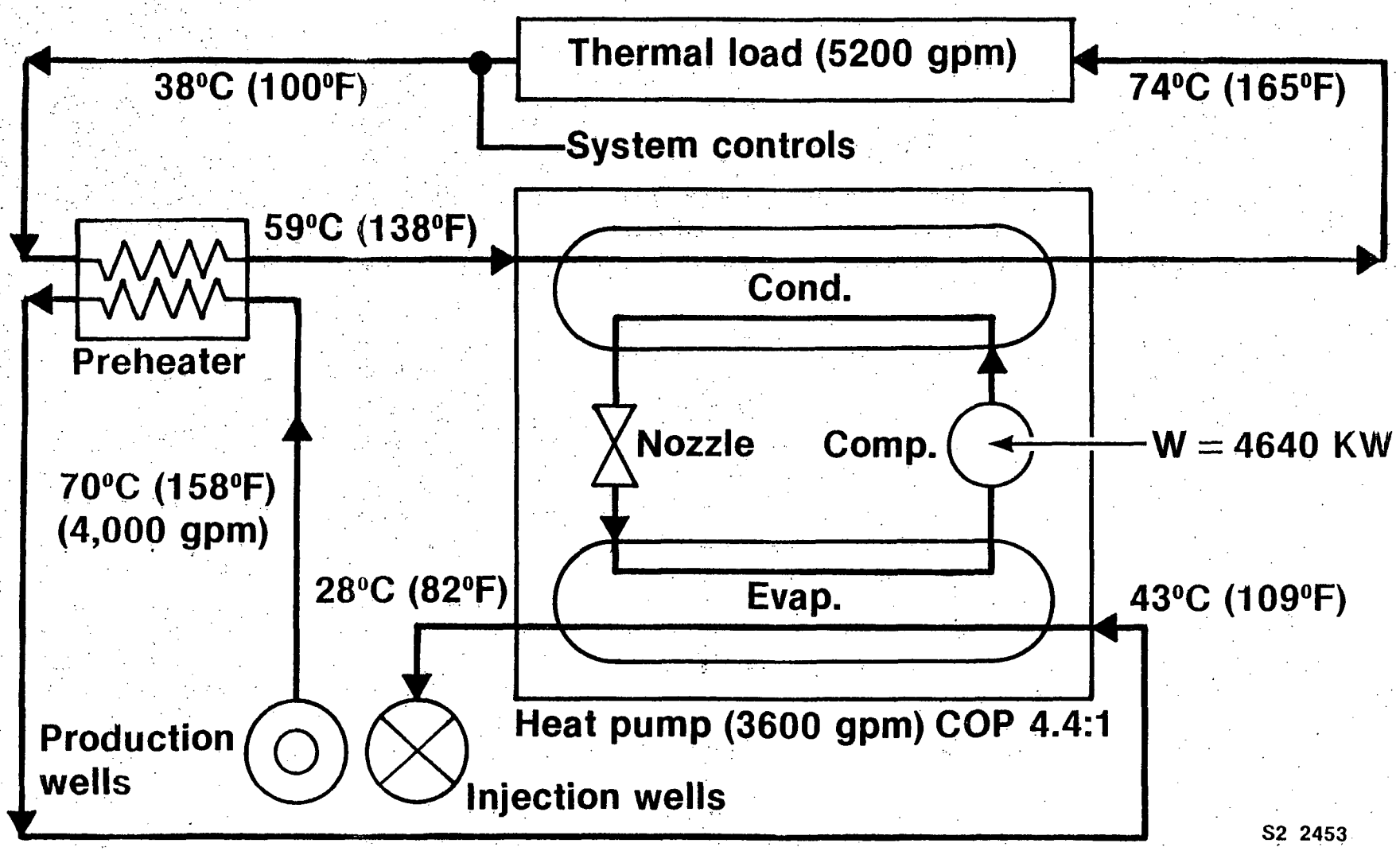

FIGURE 1

The geothermal water passes through filters before entering plate type heat exchangers thereby minimizing fouling problems on the geothermal side of the system.

Retrofit costs are included for the installation of natural and forced air convective units as well as domestic hot water tanks which operate on the distribution system. Piping materials consider the use of insulated carbon steel pipe. The use of non-ferrous piping could reduce distribution system costs and should be considered in more detailed analysis.

ECONOMIC ANALYSIS

A 20-year economic analysis was performed for each of the two cases comparing the projected geothermal system capital costs and operations and maintenance costs versus continued use of natural gas. This analysis used a 7% discount rate for future projected savings and incorporated escalation rates for natural gas prices from the Energy Information Administration Report, "The Current State of the Natural Gas Market"[1]. As this report provided projections only to 1990, no real escalation was used beyond that time. Electricity costs to operate the geothermal/heat pump systems were escalated at 2% per year. All costs are in present dollars (no inflation).

In the tabulations for each case which follow, the "savings" represent the cost of not operating the present system; the "expenses" represent the cost of operating the geothermal/heat pump system including fuel for the peaking system, electricity and maintenance; and the net revenue is the difference between savings and expenses. NPV is the present value of the Net Revenue discounted at 7%. Simple and discounted (at 7%) payback periods have also been calculated.

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1. The Current State of the Natural Gas Market, December 1981, DOE/EIA-0313.

NATURAL GAS ELECTRICAL @ 2 %

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VANDENBURG A. F. B. OPTIMISTIC

1982 $'S		YEAR	WELLHEAD PRICE	ESC. FACTOR	CUM ESC FACTOR	CUM ESC FACTOR
SAVINGS		1982	1.91	1.00	1.00	1.00
GAS	2858755	1983	2.09	1.09	1.09	1.02
OTHER	714688	1984	2.26	1.08	1.18	1.04
TOTAL	3573443	1985	3.62	1.60	1.90	1.06
		1986	3.83	1.06	2.01	1.08
		1987	3.98	1.04	2.08	1.10
EXPENSES		1988	4.15	1.04	2.17	1.13
GAS	171524	1989	4.31	1.04	2.26	1.15
ELECTR.	408614	1990	4.47	1.04	2.34	1.17
OTHER	327744					
TOTAL	907882					

INITIAL INVESTMENT 21898727

YEAR	SAVINGS	EXPENSES	NET REV
1982	3573443	907882	2665561
1983	3842854	932219	2910636
1984	4097299	955821	3141478
1985	6132852	1086456	5046396
1986	6447165	1113987	5333178
1987	6671675	1136303	5535371
1988	6926119	1160593	5765526
1989	7165596	1184165	5981431
1990	7405073	1207920	6197152
1991	7405073	1207920	6197152
1992	7405073	1207920	6197152
1993	7405073	1207920	6197152
1994	7405073	1207920	6197152
1995	7405073	1207920	6197152
1996	7405073	1207920	6197152
1997	7405073	1207920	6197152
1998	7405073	1207920	6197152
1999	7405073	1207920	6197152
2000	7405073	1207920	6197152
2001	7405073	1207920	6197152

NPV @ 7%= 32759301

NPV @ 7% 32759301

SIMPLE PAYBACK 5.25

D'CTD PAYBACK 6.18

NATURAL GAS — ELECTRICAL @ 2 %

1982 $'S		YEAR	WELLHEAD PRICE	ESC. FACTOR	CUM ESC FACTOR	CUM ESC FACTOR
SAVINGS		1982	1.91	1.00	1.00	1.00
GAS	2858755	1983	2.09	1.09	1.09	1.02
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EXPENSES		1988	4.15	1.04	2.17	1.13
GAS	171524	1989	4.31	1.04	2.26	1.15
ELECTR.	410834	1990	4.47	1.04	2.34	1.17
OTHER	582757					
TOTAL	1165115					
INITIAL INVESTMENT	26209187					

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VANDENBURG A. F. B. CONSERVATIVE

YEAR	SAVINGS	EXPENSES	NET REV		
1982	3573443	1165115	2408328		
1983	3842854	1189496	2653358	NPV @ 7%	25721083
1984	4097299	1213144	2884155		
1985	6132852	1343825	4789027	SIMPLE	6.21
1986	6447165	1371403	5075762	PAYBACK	
1987	6671675	1393767	5277907		
1988	6926119	1418106	5508013	D'CTD	8.13
1989	7165596	1441728	5723868	PAYBACK	
1990	7405073	1465535	5939538		
1991	7405073	1465535	5939538		
1992	7405073	1465535	5939538		
1993	7405073	1465535	5939538		
1994	7405073	1465535	5939538		
1995	7405073	1465535	5939538		
1996	7405073	1465535	5939538		
1997	7405073	1465535	5939538		
1998	7405073	1465535	5939538		
1999	7405073	1465535	5939538		
2000	7405073	1465535	5939538		
2001	7405073	1465535	5939538		

NPV @ 7%= 25721083