COO-4662-1
Distribution Category UC-59

FINAL REPORT

COST EFFECTIVE SOLAR HOT WATER SYSTEM

for

ECONO-TRAVEL MOTOR HOTEL

located at

Hampton, Va.

Prepared for

The Department of Energy
Grant No. EM-78-G-02-4662

Submitted by

Allen Management Company

Prepared by

Solar Systems of Virginia, Inc.
Hampton, Va.

November, 1978

DISCLAIMER

SUMMARY

This paper gives the final report of a cost effective solar hot water heating system installed on the Econo-Travel Motor Hotel at 2708 Mercury Boulevard, Hampton, Virginia. The description of the system along with the final cost breakdown, performance data and payback time are given. The payback time for the installed system will be approximately four (4) years instead of the 6.65 years estimated for the proposal. The additional savings is due to the reduction in the peak demand charge since the electric hot water heaters are not required to operate at the same time each morning as the dryers used for the laundry. As called for in the proposal to DOE, the success of the system will be determined by the reduction in the utility cost and reduced use of our fossil fuels. The results shown in the hotel's monthly electricity bills indicate that this goal has been accomplished.

INTRODUCTION

This final report gives the initial performance data of the solar hot water heating system now in operation and installed with a grant under DOE's hotel/motel solar demonstration program dated May 12, 1977. The hotel has two levels with flat roofs which make for ease of proper orientation of collectors to obtain maximum insolation. Addition roof reinforcements for these retrofit systems were not required. The collector supports were designed to withstand 100 miles per hour (25 psf) wind loads and a 20 psf dead load. The desired percentage of hot water heating for use in the rooms and laundry was 68 percent.

A saving of approximately $4,000.00 per year was calculated based on $.04 per KWH to give a 6.65 year payback time on the system which cost $24,000.00 to install. The cost of the system was underestimated by approximately $6,000.00.

DESIGN FEATURES

The system is designed to preheat and store the domestic hot water in a separate tank before it enters the electric hot water heaters. The water enters this tank at the bottom before it flows from the top of the tank and then to the backup electric heaters. While heat is being collected, a water pump forces the water from the bottom of the tank to the tube side of the shell and tube heat exchanges before it is pumped to the side near the top of the 14 foot tall tank. This vertical tank is used to obtain as much stratification as possible which increases the efficiency of the system. A third pipe from the top of the tank to the backup heater also increases the efficiency. If the same pipe were used to supply hot water to the backup heater as well as to the heat exchanger, early morning lower temperature water would be coming out of the heat exchanger than from the hot water stored at the top of the tank. Although this operational feature resulted in a higher installed cost for SSV, the additional savings was believed to justify the cost. (See Figure 1)

Another pump is placed on the shell side of the heat exchanger to force water through the collectors and then back to the heat exchanger. The heat is transferred from the solar fluid to the domestic water at this heat exchanger. The solar fluid is water and 35% proplyene glycol solution which flows through the collector tubes (.5 inch O.D. with .035 inch wall thickness).

The collectors facing due south are tilted at 30 degrees to obtain maximum insolation during the summer months when the motels are full. (See Figure 2) Final assembly of the solar collectors are made on the flat roofs of the motels to reduce the amount of framing materials and perimeter of the collectors. One collector on the roof is eight feet high and 32 or 48 feet long. The non-selective aluminum absorber plate consists of a tube-double fin extruded shape formed in a serpentine pattern. The plates are fabricated in 4 by 8 foot panels for ease of handling. The backside of the collector is supported on 5/8 inch exterior grade plywood with 6 mil polyethylene used to seal the backside of the collector. The topside of the collector is double glazed with premium grade .040 inch Sunlite as the outer surface and four mil Tedlar film as the second cover. (See Figure 3)

The tank insulation is six inches of fiberglass with exterior aluminum foil attached to prevent moisture in the insulation. The insulated tank is then enclosed in a building with exterior paneling painted to blend with the color of the hotel.

INSTALLATION EXPERIENCE

Solar Systems of Virginia, Incorporated, was fortunate to have installed a similar but smaller system on a hotel addition at this Hampton site in August, 1977. A detail drawing of this system and the collector assembly was made to plan the installation. Many discussions were made with the technician to make the field installation easier. A problem encountered with the retrofit system that did not exist with the prototype system was the cost and time required to build an enclosure around the storage tank which is 54 inches in diameter and 168 inches tall. This building caused cost overruns which were not included in the initial cost estimate.

All pumps, heat exchanger and the controls are operating as designed with no problems. The supplier of the heat exchanger ran a computer program to size the most cost effective unit with an approach temperature of 15° F. The threaded connections on the tank have presented problems because the threads were not properly cleaned after galvanizing or damaged during handling. No problems have been encountered with the Hampton code requirements. The use of the nontoxic proplyene glycol was sufficient for the city inspectors. Building and plumbing permits were required to install the system.

COST SUMMARY

The cost comparison is shown in Table IV. The estimated cost is the same as shown in the cost proposal of the grant application. The overhead and labor was very difficult to determine since detailed cost records were not kept during the installation of the solar system. Solar Systems of Virginia, Incorporated, had five grants installations at the same time. The overhead was estimated from operating cost during the months of January, February and March of 1978 as shown in Table V. Two projects were being installed during these months.

The total estimated cost of the system was $23,856. The actual system installed cost is $29,704.70 which resulted in a loss of $5,848.70.

CONCLUSION

This report has presented a cost effective solar heating system at an installed cost of $24,000. The system would also be cost effective at a reasonable installed cost of $35,000.00 as shown in Figure IV. This is accomplished by (1) collector design to match the hot water needs,

(2) system sized to meet the hot water needs during the summer months, and (3) maximum system performance when the system reduces the peake demand charge.

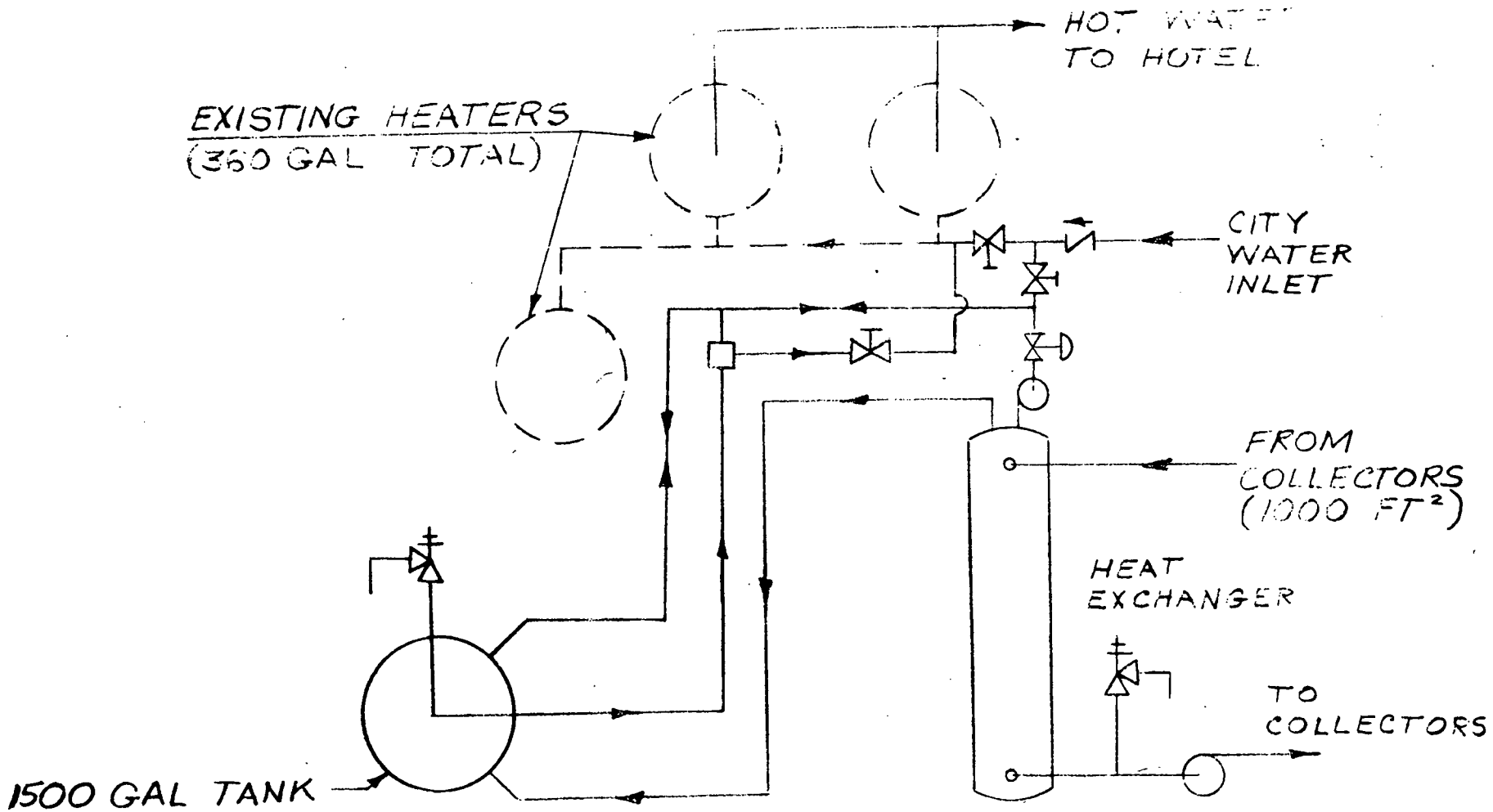

FIGURE - 1 HOTEL PIPING SCHEMATIC

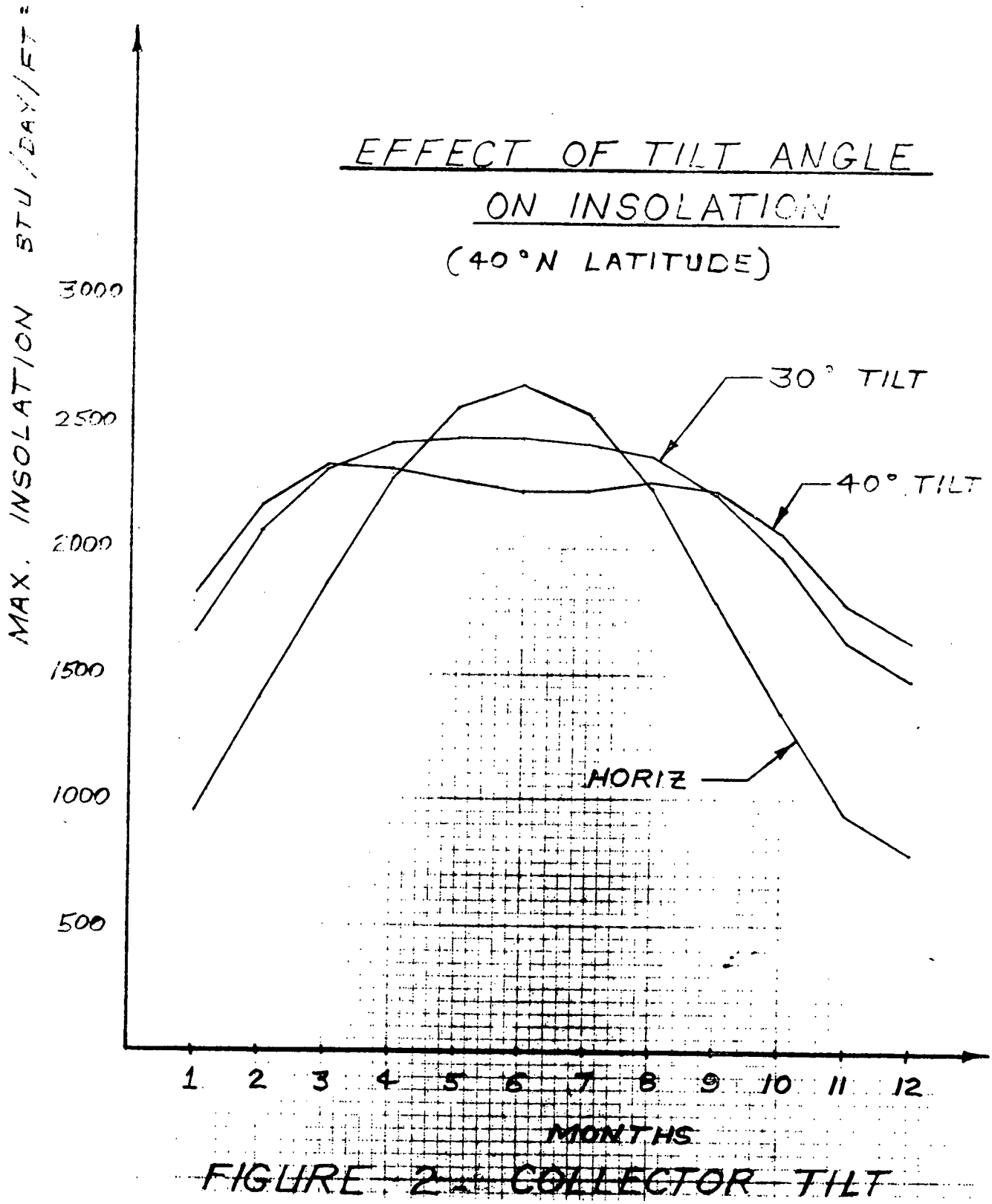

FIGURE 2 - COLLECTOR TILT

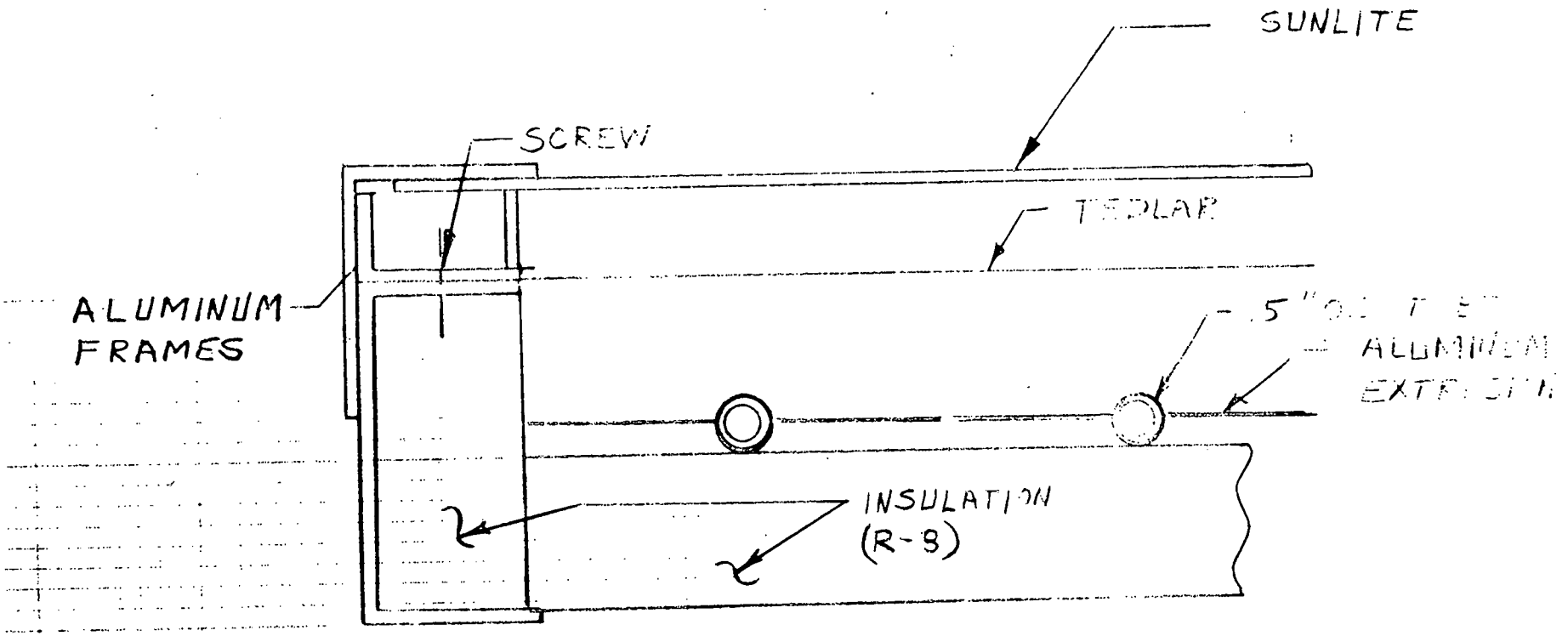

FIGURE - 3

COLLECTOR DETAIL

NO SCALE

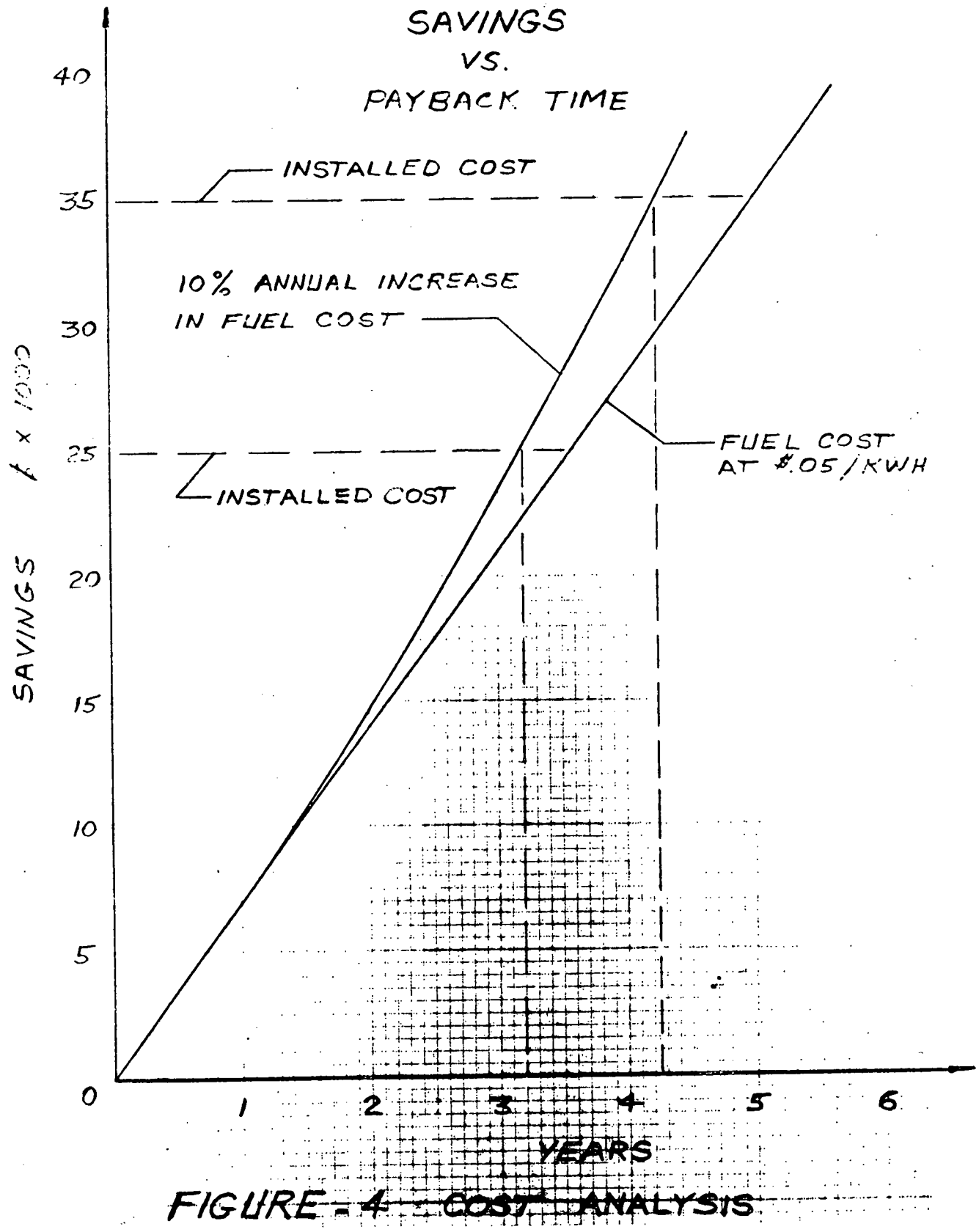

FIGURE - 4 - COST ANALYSIS

TABLE I
COMPARISON OF ELECTRICITY USED
March & April - 1977 & 1978
Hampton Property

	% Change March to April	48 units 1977	% Change 1977 - 1978	72 units 1978	% Change March to April
MARCH					
Total Occupied Rooms		1323	19.20%	1577	
Total Bill		$1,580.42	73.36%	$2,739.87	
Kilowatthours Used		33,100	79.15%	59,300	
Demand		137	53.28%	210	
Average Mean Temperature		54.7°F		46.1°F	
APRIL					
Total Occupied Rooms	12.77%	1492	21.58%	1814	15.03%
Total Bill	(4.78%)	$1,504.82	10.94%	$1,669.50	(39.07%)
Kilowatthours Used	1.5.%	33,600	(0.89%)	33,300	(43.84%)
Demand	(22.63%)	106	22.64%	130	(38.10%)
Average Mean Temperature		61.9°F		57.2°F	

TABLE II
SOLAR ENERGY
USED
PER MONTH
(Hampton, Va.)

Month	Btu/Mo. $X10^6$	KWH	Cost *	Demand ** Savings	Total Cost
1	11.4	3338	$167	$316	$483
2	15.4	4509	$225		$541
3	20.2	5915	$296		$612
4	21.4	6266	$313		$629
5	23.4	6852	$343		$659
6	19.4	5680	$284		$600
7	19.0	5563	$278		$594
8	19.4	5680	$284		$600
9	19.4	5680	$284		$600
10	18.0	5270	$264		$580
11	12.6	3690	$184		$500
12	9.6	2811	$140	$316	$456
	$209x10^6$	61253	$3062		$6854

* Cost based on $.05/KWH

** Based on reduction of 60/Mo. and rate of $5.26/KW demand

TABLE III
HAMPTON SOLAR SYSTEM
PERFORMANCE DATA

	1977			1978		
	KWH USED	KW DEMAND CHARGE	ELECTRIC COST	KWH USED	KW DEMAND CHARGE	ELECTRIC COST
Jan.	58700	148	$2141	56800	200	$2603
Feb.	47300	138	$1966	58500	190	$2504
Mar.	33100	137	$1580	59300	210	$2740
Apr.	33600	106	$1505	33300	130	$1670 ▲
May	26200	94	$1201	31100	130	$1553
June	30500	103	$1495	31900	110	$1538
July	40800	122	$1896	31100	100	$1641
Aug.	42900	130	$1966 *	40200	110	$1675
Sept.	42700	160	$2115	40400	100	$1760
Oct.	103800	160	$4898 •	28200	100	$1450
Nov.	33500	140	$1660			
Dec.	45900	180	$2044			

* 24 Unit addition added with solar system to heat domestic hot water.
• Switched to new billing schedule
▲ Operation of solar system for domestic hot water on the 48 unit motel.

SOLAR SYSTEMS OF VA., INC.

TABLE IV

COST COMPARISON

	ESTIMATED	ACTUAL
MATERIALS:		
Collectors	3,700	3,409
Tank Foundation	2,500	2,430
Pumps	500	435
Heat Exchanger	1,300	500
Controller	50	50
Insulation	400	590
Wood for Support	200	2,505
Miscellaneous	1,000	4,754
Sub-Total	9,650	14,673
10% OH	965	
LABOR:		
Collector Installation	2,400	1,936
Collector Supports	2,400	1,970
Pipe Installation	3,600	2,262
Sub-Total	8,400	6,168
10% OH	840	
Sub-Total	9,240	
General Expenses	1,972	8,864
Total Cost	21,687	
Profit	2,169	
Total	23,856	29,705

SOLAR SYSTEMS OF VA., INC.

TABLE V

COST SUMMARY FOR
HAMPTON PROJECT

A. COLLECTOR ARRAY:

1. Materials:

Panel Extrusion	$ 580.00
Paint and Primer	30.00
Insulation	355.00
Tedlar	215.00
Aluminum Tedlar Frames	190.00
Aluminum Perimeter Frames	182.00
Aluminum Angles	150.00
Silicone Caulking	80.00
Screws	110.00
Sun-Lite Glazing	512.00
Aluminum Flat Bar	40.00
Total Materials =	$ 2,444.00

2. Labor:

Panel Fabrication	-	80 hrs.
Tedlar Frames		120
Collector Frames		32
Roof Assembly		120
Total		352 hrs.
Labor Cost @ $5.50/hr.	=	$ 1,936.00
Total Collector Array =		$ 4,380.00

B. SUPPORTS FOR COLLECTORS:

1. Materials:

Baseplate w/Copper Cover		=	$ 945.00
Wood Frames			2,505.00
Nails			20.00
	Materials Total	=	$ 3,470.00

2. Labor:

Attaching Baseplate			$ 1,000.00
Building Supports			970.00
	Labor Total	=	$ 1,970.00
Total Col.	Support	=	$ 5,740.00

C. PIPING/FITTINGS:

Materials:		=	$ 2,845.00
Labor 184 hrs. @ $5.50/hr.		=	1,010.00
Master Plumbing & Permits		=	180.00
	Total	=	$ 4,035.00

D. INSULATION:

Materials		=	$ 590.00
Labor: 48 hrs. @ %5.50		=	270.00
	Total	=	$ 860.00

E. EQUIPMENT:

Pumps	$ 435.00
Heat Exchanger	500.00
Expansion Tank	20.00
Valves/Gauges	1,000.00
Air Vents	21.00
Air Separator	22.00
Anti-Freeze	80.00

E. EQUIPMENT: Continued

Tempering Valve			$ 70.00
Check Valve			50.00
Zone Valve			36.00
	Total		$ 2,334.00

F. CONTROLS:

Controller w/wire		=	$ 50.00
Wiring 9 hrs. @ $5.50/hr.		=	50.00
	Total		$ 100.00

G. ELECTRICAL:

Breakers, Relays, etc.		=	$ 100.00
Wiring 24 hrs. @ $5.50/hr.		=	132.00
	Total	=	$ 232.00

H. TANK/INSULATION:

1. Materials: $

Concrete			115.00
Re-Bar			35.00
Basering for Tank			95.00
Tank			1,910.00
Crane			65.00
Delivery			120.00
Insulation (6" Fiberglass)			90.00
	Material Total		$ 2,430.00

2. Labor: 32 hrs. @ $5.50 = $ 180.00

Total Cost for Tank = $ 2,610.00

I. TANK HOUSE:

1. Materials:

Wood Support		$ 240.00
Siding		214.00
Nails		20.00
Paint		36.00
	Materials Total	$ 510.00
2. Labor: 80 hrs. @ $5.50	=	440.00
Total Cost for House	=	$ 950.00
Total Materials Cost	=	14,773.00
Total Labor Cost	=	6,168.00
Total		$20,941.00

OVERHEAD:

2 Projects were worked during January, February and March. Take 1/2 of total overhead as part of Hampton Project.

January	$5,500.30
February	4,196.61
March	6,758.49
Total	$12,755.40

1/2 for Hampton	=	$ 6,377.70
Administrative (Engineeeing, Permits, General Contracts, Etc.)	=	$ 2,386.00
Total Cost	=	$29,704.70

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