F I N A L R E P O R T

COST EFFECTIVE SOLAR HOT

WATER SYSTEM

FOR

ECONO-TRAVEL MOTOR HOTEL

located at

CHESAPEAKE, VIRGINIA

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MASTER

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SUMMARY

This paper gives the final report of a cost effective solar hot water heating system installed on the Econo-Travel Motor Hotel at 4725 W. Military Highway, Chesapeake, Virginia. The description of the system along with the final 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. Additional 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. 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 exchangers 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% propylene 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 hotel is 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 Sun-lite as the outer surface and one mil teflon 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 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 a 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.

The roof at Chesapeake caused delays and required additional time to get the work completed. The built-up roof leaked during the entire installation of the collectors which caused many hours of roof repair that should have been devoted to the collector installation. Finally, an experienced roofer was called in to add felt and many gallons of hot tar to repair the damaged roof that was caused by technicians walking on the roof.

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 threads were not properly cleaned after galvanizing or damaged during handling. No problems have been encountered with the Chesapeake

code requirements. The use of the non-toxic propylene glycol was sufficient for the city inspectors. Building and plumbing permits were required to install the system.

PERFORMANCE DATA

The owners of the hotels and Solar Systems of Virginia, Inc. are satisfied with the performance of the system. After initial check out of the system, the system has been trouble free. The system which went into operation on August 11, 1978 was checked for leaks on that day and then all lines were insulated. The system has been operating satisfactory since without requiring attention. The temperature of the water - 35% propylene glycol solution out of the collectors is 100° F to 170° F depending on the storage tank temperature.

A comparison of the electricity used for the months of September thru November shows a reduction in the KWH used as well as demand charge when comparison is made between 1977 and 1978. (See Table I). It is difficult to determine the actual savings based on only three months of operations since some months earlier in 1978 had an electricity bill less than 1977. However, if we average out the savings for September thru November in the reduction in electricity used at \$.05/KWH and the reduction in demand charge at \$5.26/KW we will save approximately \$6,626. each year. If a conservative annual savings of \$6,000.00 is used, the system payback time will be 4 years. With an installed cost of \$35,000. the system will still have a payback time less than 5 years based on a 10% annual increase in fuel cost.

COST SUMMARY

The cost comparison is shown in Table II. 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, Inc., had five grants installations at the same time. The overhead was estimated from operating cost during the months of April, May and June of 1978 as shown in Table II. Two projects were being installed during these months. This system was the only one being installed during the months of July and August.

The total estimated cost of the system was \$23,856. The actual system installed cost is \$30,644.00 which resulted in a loss of \$6,788.00.

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.

CHESAPEAKE SOLAR SYSTEM

PERFORMANCE DATE

TABLE I

1 9 7 7				1 9 7 8			
MONTH	KWH USED	KW DEMAND CHARGE	VEPCO BILL	KWH USED	KW DEMAND CHARGE	VEPCO BILL	
January	N/A	N/A	N/A	52700	147	2,177.57	
February	N/A	N/A	N/A	57400	154	2,418.84	
March	N/A	N/A	N/A	54900	150	2,397.46	
April	N/A	N/A	N/A	25800	150	1,381.93	
May	23500	084	1,193.63	26000	114	1,301.31	
June	29000	084	1,477.85	19800	088	1,203.97	
July	38300	101	1,823.48	31200	100	1,692.91	
August	36100	096	1,717.13	31300	096	1,687.72	
September	32000	088	1,594.33	27400	96	1,588.07	*
October	29900	104	1,396.84	18200	76	1,008.10	
November	28600	120	1,398.51	22500	80	1,130.63	
December	46300	135	1,921.33				

*System installed on August 11, 1978

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TABLE II

CHESAPEAKE, VIRGINIA

COST COMPARISON

	ESTIMATED	ACTUAL
<u>MATERIALS:</u>		
Collectors	\$ 3,700.	\$ 4,336.
Tank Foundation	2,500.	2,699.
Pumps	500.	383.
Heat Exchanger	1,300.	500.
Controller	50.	50.
Insulation	400.	426.
Wood for Support	200.	2,505.
Miscellaneous	1,000.	5,025.
Sub-Total	\$ 9,650.	\$ 15,924.
10% Overhead	965.	
<u>LABOR:</u>		
Collector Installation	2,400.	1,936.
Collector Supports	2,400.	1,452.
Pipe Installation	3,600.	2,082.
Sub - Total	\$ 8,400.	5,470.
10% Overhead	840.	
Sub-Total	\$ 9,240.	
<u>GENERAL EXPENSES:</u>	\$ 1,972.	\$ 9,250.
TOTAL COST	\$ 21,687.	
PROFIT	2,169.	
TOTAL	\$ 23,856	\$ 30,644.

SOLAR SYSTEMS OF VA., INC.

TABLE III
COST SUMMARY FOR
CHESAPEAKE PROJECT

A. COLLECTOR ARRAY:

1. MATERIALS:

Panel Extrusion	\$ 580.
Paint & Primer	30.
Insulation	427.
Teflon	215.
Aluminum Teflon Frames	190.
Aluminum Perimeter Frames	182.
Aluminum Angles	150.
Silicone Caulking	80.
Screws	110.
Sun-lite Glazing	512.
Aluminum Flat Bar	<u>40.</u>
Total Materials	\$2,516.

2. LABOR:

Panel Fabrication	80 Hours
Teflon Frames	120 "
Collector Frames	32 "
Roof Assembly	<u>120 "</u>
Total Hours	352
Labor Cost @ \$5.50/hrs.	<u>\$1,936.</u>

TOTAL COLLECTOR ARRAY

\$ 4,452.

B. SUPPORTS FOR COLLECTORS:

1. MATERIALS:

Baseplates w/copper cover (subcontract)	\$1,800.
Wood Frames	2,505.
Nails	<u>20.</u>
Total Materials	\$4,325.

B. Supports for Collectors: Continued

2. LABOR:

Collector Supports = 264 Hours

264 Hours @ \$5.50/hour = \$ 1,452.

TOTAL COLLECTOR SUPPORT

\$ 5,777.

C. PIPING AND FITTINGS:

1. Materials \$ 2,845.

2. Labor 184 Hours @ \$5.50 1,010.

TOTAL COST

\$ 3,855.

D. INSULATION:

1. Materials \$ 426.

2. Labor 48 Hours @ \$5.50 270.

TOTAL COST

\$ 696.

E. EQUIPMENT:

Heat Exchanger \$ 485.

Pumps 383.

Expansion Tank 22.

Valves/Gauges 1,000.

Air Vents 21.

Air Separators 22.

Anti-Freeze 80.

Temper Valves 74.

Check Valves 50.

Zone Valves 36.

TOTAL COST

\$ 2,173.

F. CONTROLS:

Controllers - w/wire \$ 50.

Wiring - 9 Hours @ \$5.50 50.

TOTAL COST

\$ 100.

G. ELECTRICAL:

Breakers, Relays, etc. \$ 100.

Wiring - 24 Hours @ \$5.50 132.

TOTAL COST

\$ 232.

H. TANK/INSULATION:

1. MATERIALS:

Concrete	\$ 226.
Re-Bar	50.
Tank	2,259.
Crane	62.
Insulation (6" Insulation)	90.
Barracade	<u>12.</u>

Total Materials \$ 2,699.

2. LABOR:

32 Hours @ \$5.50 \$ 180. 180.

TOTAL TANK COST \$ 2,879.

I. TANK HOUSE:

1. MATERIALS:

Wood	\$ 741.
Paint	29.
Nails	<u>20.</u>

Total Materials \$ 790.

2. LABOR:

80 Hours @ \$5.50 \$ 440. 440.

TOTAL COST OF TANK HOUSE \$ 1,230.

TOTAL MATERIAL COST \$ 15,924.

TOTAL LABOR COST 5,470.

TOTAL \$ 21,394. \$ 21,394.

OVERHEAD

Two (2) Projects were worked on during April, May; June. One (1) project during July and August.

1/2 April, May, June	\$ 2,466.
July, August	4,384.
Administrative, (Eng., Permits, etc.)	<u>2,400.</u>

Total Overhead \$ 9,250. 9,250.

TOTAL COST \$ 30,644.

FIGURE-1 HOTEL PIPING SCHEMATIC
(SYSTEM FOR 48 UNIT HOTEL)

FIGURE - 3
COLLECTOR DETAILS
NO SCALE

FIGURE 2 - COLLECTOR TILT

SAVINGS VS. PAYBACK TIME

FIGURE - 4 , COST ANALYSIS