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EVALUATION OF A RESIDENTIAL SOLAR AIR HEATING SYSTEM

Interim Progress Report, August 1976—May 1977

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PREPARED FOR
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WASHINGTON, D. C.

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EVALUATION OF A RESIDENTIAL SOLAR AIR HEATING SYSTEM

The comparative performance of Solar House II collectors (air heater) and Solar House I collectors (liquid heater) are plotted on Figure 1 for January through the middle of May 1976. The heat delivered by the collectors are plotted vertically against the months along the horizontal axis. The bar on the left, for each month, is for Solar House II and the bar on the right is for Solar House I. It will be noted that the air system operates longer during the day, on average, than the liquid system and collects about 30 percent more heat. The principal reason for this is the stratification of temperature in the rock bed storage, as opposed to a non-stratified water storage tank in the liquid system. Because the air delivered to the collector in the morning is always at room temperature (during the heating season) collection of heat begins earlier in the morning for air systems than liquid systems. Also, in the afternoon, the liquid system stops earlier in time than the air system because the water temperature in storage builds up during the day. For example, the liquid system will build up the tank temperature to, say 140°F , by 2 p.m., and the system will stop collecting when the collectors cannot deliver liquid heated to greater than 140°F . In an air system however, as long as the air temperature from the collector is greater than the bottom temperature of the stratified rock bed, which is at room temperature, the system will continue to collect useful heat. As a consequence, on average, the air system in Solar House II collected about 30 percent more useful heat than the liquid system in Solar House I.

The air system in Solar House II, unfortunately, has leakage at the collector due to the nature of its assembly, and the air that leaks into the system has to "exfiltrate" from the house giving an apparent large heat load. Thus, increased quantity of heat collected is discharged from the building. There is another feature of Figure 1 which appears to be anomolous. It will be noted that the total available sunshine is different for Solar House I and II during February and March. That anomaly arises because the average daily energy rates were calculated over different number of days in each month for each house. In April, the data were averaged over exactly the same number of days and in May, Solar House II data are averaged over 3 more days than Solar House I. The reason for the difference in the numbers of days used in the averages is that the instrumentation in both houses had difficulties over different days of the month and data for some days are missing from the records of both systems. The reliability in obtaining continuous data was improved significantly in both houses during early fall, 1976.

It should also be noted in Figure 1, that the daily collector efficiency based upon the solar radiation available when the collector is operating, averaged over the month, is about 35 percent for both systems. During the final phase of this project, the efficiencies over longer periods will be compared.

The performance of the air collectors on Solar House II obtained in 1977 is compared to performance in 1976 in Figure 2. The data for April 1977 has not yet been analyzed. It will be noted that the collectors operated for a greater proportion of the sunshine hours in 1977 than in 1976. This is because the control strategy was changed slightly before the 1976-77 heating season from the 1975-76 season. The average daily

radiation in February and March, 1977 was less than the corresponding months in 1976, but had they been the same, the change in strategy could have resulted in about 10 percent greater heat collection. There are, of course, some trade-offs to be made, and in this case, because the collectors operate over a longer period of the day, the average daily collector efficiencies in February and March (the only months available for comparison) dropped about 2 percent, from 37 percent to 35 percent in February and 34 percent to 32 percent in March. The sacrifice in efficiency for greater total heat collection during the day must be evaluated in terms of the total electric energy required to collect the extra solar energy. That part of the study must be made after the entire season's data are analyzed.

In Figure 3, is shown the comparison in system performance for Solar House II and Solar House I in terms of percentage of total space and water heating load supplied by solar energy. Solar House II data are the left bars in each month and Solar House I data are the right bars. In the 1976 comparison year, there is no conclusive evidence that either system provides a greater fraction of the seasonal load. Both systems were designed to provide approximately 75 percent of the annual space and water heating load, and the design targets are reasonably achieved. In February, 1976, the air system provided 65 percent of the total requirement while the liquid system provided 76 percent. In March, based on a few days of data, the performance was substantially the same. In April the air system provided a greater fraction of solar heat to the total need, but the use of the heat was different, more being used for domestic water heating in Solar House I than in Solar House II.

The data for 1977 have not yet been fully analyzed for both solar houses and therefore, a complete comparison cannot be made. At this stage in the evaluations, it can be stated that either system can be designed to achieve the target fraction of the total annual heat requirements.

In Figure 4 the system performance for Solar House II during 1976 and 1977 is compared for the available data. The data for 1977 are the right bars, and the data for 1976 are to the left. The data for February and March, 1977 compared to 1976 indicate that approximately 10 percent more solar heat was collected towards the total heat requirement in 1977 as compared to 1976 performance. This, again, was largely due to a change in control strategy. Whether or not an optimum strategy has been achieved requires more experimentation. To this end, a study is being made to develop a technique for determining the optimal control strategy for solar heating and cooling systems.

The heating season for 1976-77 will terminate on May 13, 1977. The season's data will be evaluated and provided in the final report which is in progress.

Figure 1. Comparative Collector Performance, Solar House I and II, (1976)

Figure 2. Average Collector Performance, Solar House II, 1976 and 1977.

Figure 3. Comparison of System Performance Partial Heating Season in 1975-76.

Figure 4. Distribution of Solar and Auxiliary to Total Space and DHW Load, CSU Solar House II, 1976 and 1977.