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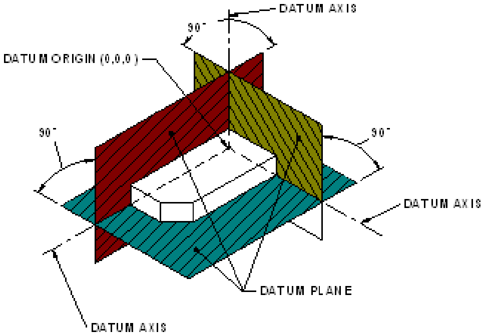

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An Introduction to Planning Solar Water Heating Systems

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CONTENTS

1. INTRODUCTION

1.1 PURPOSE AND SCOPE. This course provides guidance for the planning of standard active solar energy systems to preheat domestic and service water. The systems treated by this publication are liquid based. Guidelines apply to the larger commercial-scale applications that require an effort on the part of the designer, as opposed to residential-sized "packaged" systems, which in the past have been available from a number of manufacturers. The concepts developed in this document are targeted for new construction, although most are also appropriate for retrofit applications.

2. REQUIREMENTS

2.1 INTRODUCTION. In view of a history of fluctuating energy costs and uncertain availability of fossil fuels, the economic feasibility study of any energy-related project becomes the foundation of the design process. For the case of renewable energy, an economic feasibility analysis should be performed for all new construction to determine whether the use of renewable forms of energy will result in a net monetary savings to the owner. Furthermore, installation of a renewable energy system is recommended if it is deemed economically feasible. This publication provides the tools necessary to perform a feasibility study in accordance with these required procedures.

2.2 ECONOMIC EVALUATION

2.2.1 SCREENING TOOL. To evaluate the feasibility of designing and installing an active solar preheat system, the first step will be to use the Solar Payback screening tool developed by the Construction Engineering Research Laboratory (CERL). The tool is a Microsoft Excel spreadsheet that contains screening criteria developed by the National Renewable Energy Laboratory (NREL). The program is a quick, straightforward tool that requires minimal input (general site location as well as starting point energy costs and system costs) to calculate numerous payback periods for the two most common solar hot water technologies (flat-plate and evacuated tube collectors) when used to displace either electricity or natural gas energy costs.

2.2.2..DETAILED ANALYSIS AND STUDY. If the results of the Solar Payback screening tool indicate that an active solar hot water system should be considered further, then the next step will be to perform a detailed life-cycle cost analysis (LCCA) to determine the most effective design alternative to develop. LCCA calculations and reports will be performed in accordance with an economic analysis. Computer calculations will be performed using an economic analysis program, such as the Life Cycle Cost In Design (LCCID) computer program. Information defined in this document will be used in the development of the LCCA calculations. For additional guidance in the development of the LCCA calculations, refer to the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) publication “Active Solar Heating Systems Design Manual”. The manual was developed by ASHRAE, the Solar Energy Industries Association (SEIA), the American Consulting Engineers Council (ACEC), and the Department of Energy (DOE) contractors and is intended to give solar designers an effective means to use the collective knowledge of government and industry to better select options for improving the quality and energy efficiency of solar systems.

2.3 FEASIBILITY DISCUSSION

2.3.1 SYSTEM SELECTION. If one or more systems show a positive LCC savings, the system with the highest LCC savings must be designed. In the case of two systems LCC savings having approximately equal values, the system with the highest savings-to-investment ratio (SIR) should be chosen for detailed design. If no system shows a positive LCC savings, an active solar energy system is not to be considered for the project.

2.3.2 SUMMARY. Examination of many feasibility studies shows that the service water preheating application is typically the most cost-effective alternative. Space heating by use of solar energy is best accomplished by passive solar building design. Solar cooling of any form is seldom cost-effective, largely due to prohibitive equipment and M&R costs.

2.4 FUNDING. One of the biggest obstacles to using solar hot water technologies is often the inability to obtain the funding for the initial capital costs, even though a-lifecycle cost analysis might show that the investment would pay for itself several times over. Funding for energy projects in general, and renewable energy projects in particular, has been consistently reduced over the last several years. There are still opportunities for funding these projects.

3. SYSTEM SELECTION, PLANNING, AND COORDINATION

3.1 INTRODUCTION. This discussion provides criteria for selection of a specific type and configuration of solar energy system, and discusses special issues that must be considered. Once the system type is selected, coordination with the architect and structural engineer is critical for determining estimates of roof area, roof and collector support, and equipment space requirements. It should be noted that this discussion applies to the design of systems for the northern hemisphere. Appropriate corrections should be made for the design of these systems in the southern hemisphere.

3.2 STANDARD SYSTEM TYPES. To meet the owner's goal of standardizing solar energy installations, the following system types have been selected for use on all active solar installations.

3.2.1 CLOSED-LOOP SYSTEM. The closed-loop solar energy system has proven to be very reliable when designed and maintained properly, largely due to its ability to successfully withstand freezing temperatures. Freeze protection is provided by circulating a solution of propylene glycol and water through a closed collector loop. Figure 3-1 is a schematic of the closed-loop system.

3.2.1.1 SYSTEM OPERATION

3.2.1.1.1 SOLAR LOOP. The differential temperature controller activates the solar loop pump in the collector loop when the temperature difference between the collector and storage is large enough for energy to be collected. The propylene glycol solution circulates in a pressurized closed-loop through the solar collector to an external heat exchanger. An expansion tank is provided to account for thermal expansion of the fluid in the collector loop, stagnation, and over-pressure protection.

3.2.1.1.2 STORAGE LOOP. The control system activates the storage loop pump simultaneously with the collector loop pump. Water in the storage loop is heated by the solution in the heat exchanger and passed to the solar storage tank. When there is a hot water demand, cold water is drawn into the solar storage (preheat) tank and solar heated water is sent to an auxiliary water heater where it is heated further (if necessary) and sent to the load.

3-2.1.2 DESIGN PRECAUTIONS. While the closed-loop solar energy system can provide reliable service in any climate, certain design precautions must be taken.

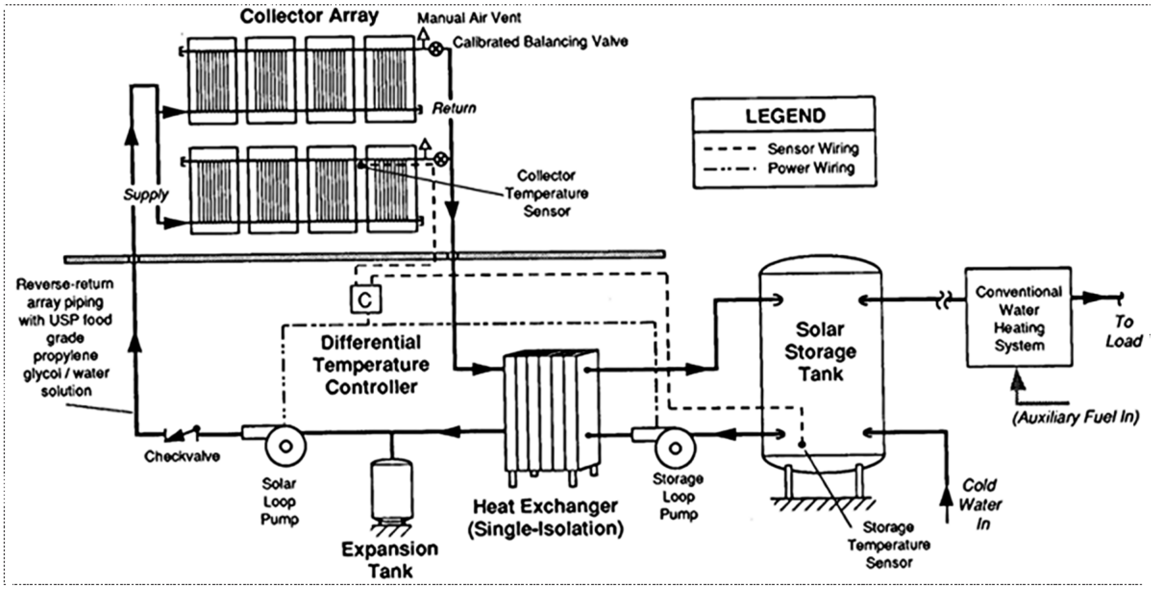

Figure 3-1

Closed-loop antifreeze system

3.2.1.2.1 COLLECTOR LOOP CHECK VALVE. The check valve shown in the collector loop is required to prevent "reverse thermosiphoning". This phenomenon can occur on cold nights when the collector loop is not active. Warm solution from the lower part of the loop (usually located indoors) becomes buoyant and rises toward the top of the loop where it becomes colder. This cold, denser solution then drops to the bottom of the loop, often passing through the heat exchanger and removing energy from the storage loop. Extreme cases have resulted in frozen heat exchangers. Care should be taken to locate the check valves so that the fluid in the collector loop can be drained if necessary.

3.2.1.2.2 PIPING AND COMPONENT PROTECTION. Fluid problems and associated corrosion and maintenance issues are a common cause of closed-loop system failure. However, results from the testing of degraded, uninhibited propylene glycol indicate that with proper design, a closed-loop system may run without fluid maintenance for up to 20 years. Designers should ensure that non-ferrous piping and components are used

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