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 with 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.
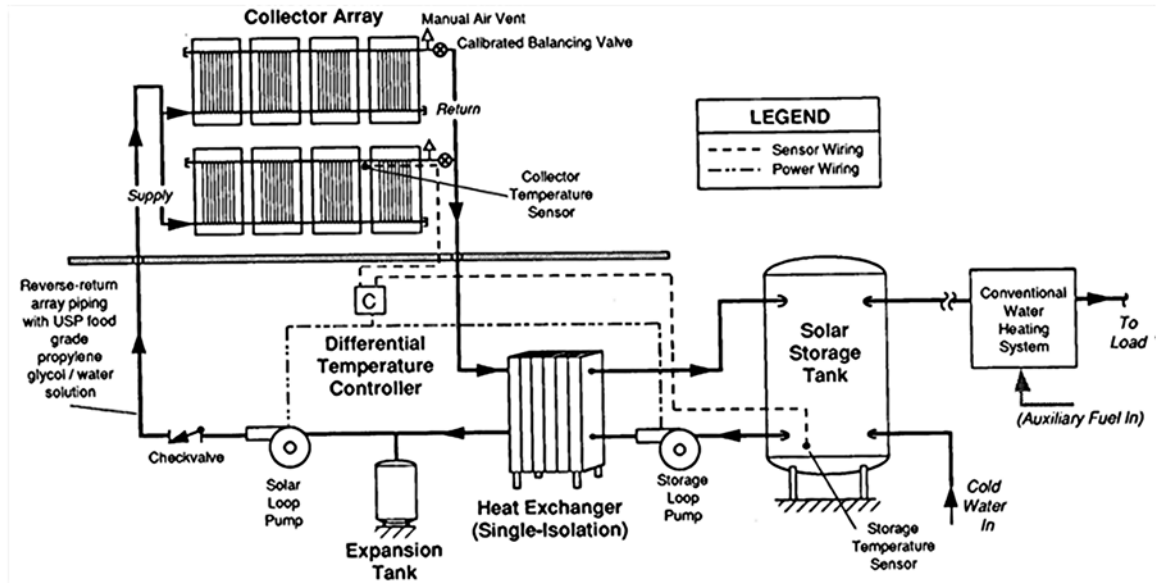
Figure 3-1

Closed-loop antifreeze system

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.

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 whenever possible, that no air is allowed to be drawn into or contained within the system, and that the expansion tank and pressure relief valves are correctly sized to prevent loss of solution and opening of the collector loop in the event of high pressure stagnation.

3.2.1.2.3 COLLECTOR LOOP AIR VENT. The manual air vent shown at the top of the collector loop allows air that has been released from solution to be purged. Propylene glycol has a strong affinity for air, and dissolved oxygen in solution can greatly impair system performance by contributing to corrosion.

3.2.1.2.4 MIXING VALVES. Mixing valves are typically used to provide a high temperature limit to the load or to supply the load with a specific hot water temperature. It is important to ensure that the cold-water leg between the mixing valve and the cold water supply to the solar storage tank is not used for connection to any other fixture. Experience has shown that backflow through the storage tank can occur which sends solar heated water to a cold water user. Although a check valve can be used in the cold water supply to prohibit back flow, it is best to avoid this situation whenever possible.

3.2.2 DIRECT CIRCULATION SYSTEM. The direct circulation system is the most basic active solar energy system recommended for adoption. It should be limited to use in locations where there are no freezing days, and where the water supply is of sufficiently high quality (i.e., not highly scaling). The entire system operates at existing

water supply pressure and circulates potable water through the collectors directly to storage. Figure 3-2 is a schematic of a direct circulation system.
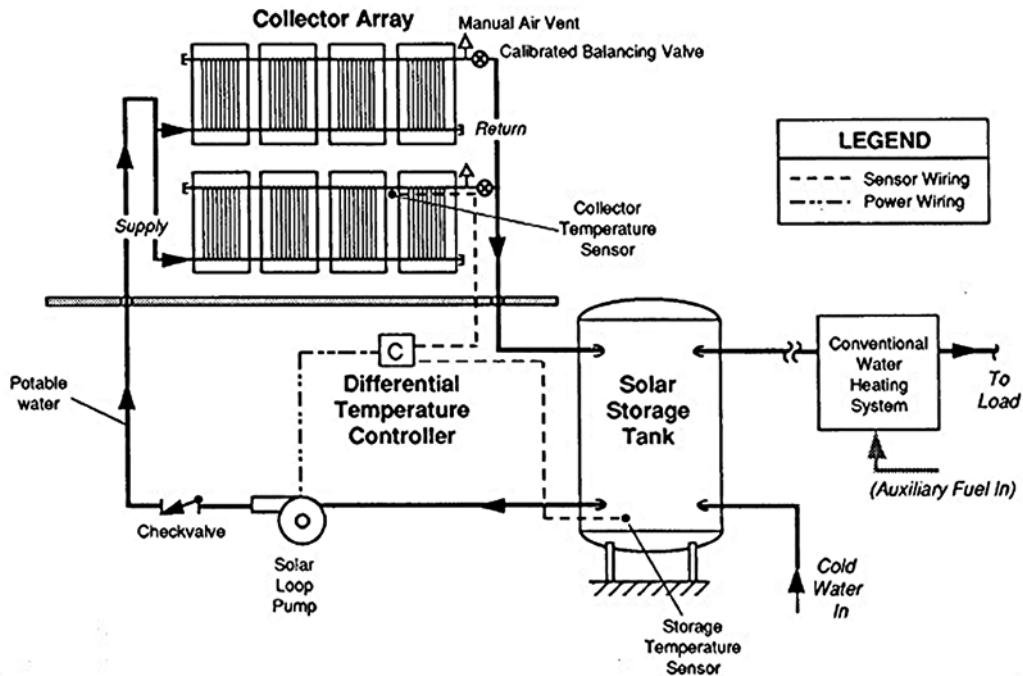

Figure 3-2

Direct circulation system

3.2.2.1 SYSTEM OPERATION

3.2.2.1.1 COLLECTOR LOOP. The collector loop pump is activated when the collector temperature is large enough for energy to be collected and transferred to the solar storage tank.

3.2.2.1.2 STORAGE LOOP. The solar storage tank is used as a preheater for a conventional water-heating unit, which is placed in series between the solar storage tank and the load. When a demand for hot water occurs, cold water is drawn into the solar storage tank where it then passes through the collector array (if activated) or on to the conventional water heater.

3.2.2.2 WATER SUPPLY. Due to their inability to withstand freezing temperatures, there is a relatively small market for direct circulation systems. However, because of their simplicity and straightforward operation, they have proven superior when used at the proper location. An overwhelming consideration for the success of these systems is the quality of the local water supply. Water is circulated directly through the collectors, so that corrosion and scale buildup can be a major cause of failure in these systems. In many regions where the water supply is of poor quality, it is necessary to treat the incoming water supply so that it is within the prescribed quality limits.

3.3 SYSTEM SELECTION. The standard systems described represent proven designs that are both simple and reliable. System selection is largely based on the site location, with the number of freezing days being the critical factor. Also important are the estimated load size and the water quality at the site. Figure 3-3 is a flowchart to facilitate the system selection process. This figure allows only service water preheating applications to be chosen.
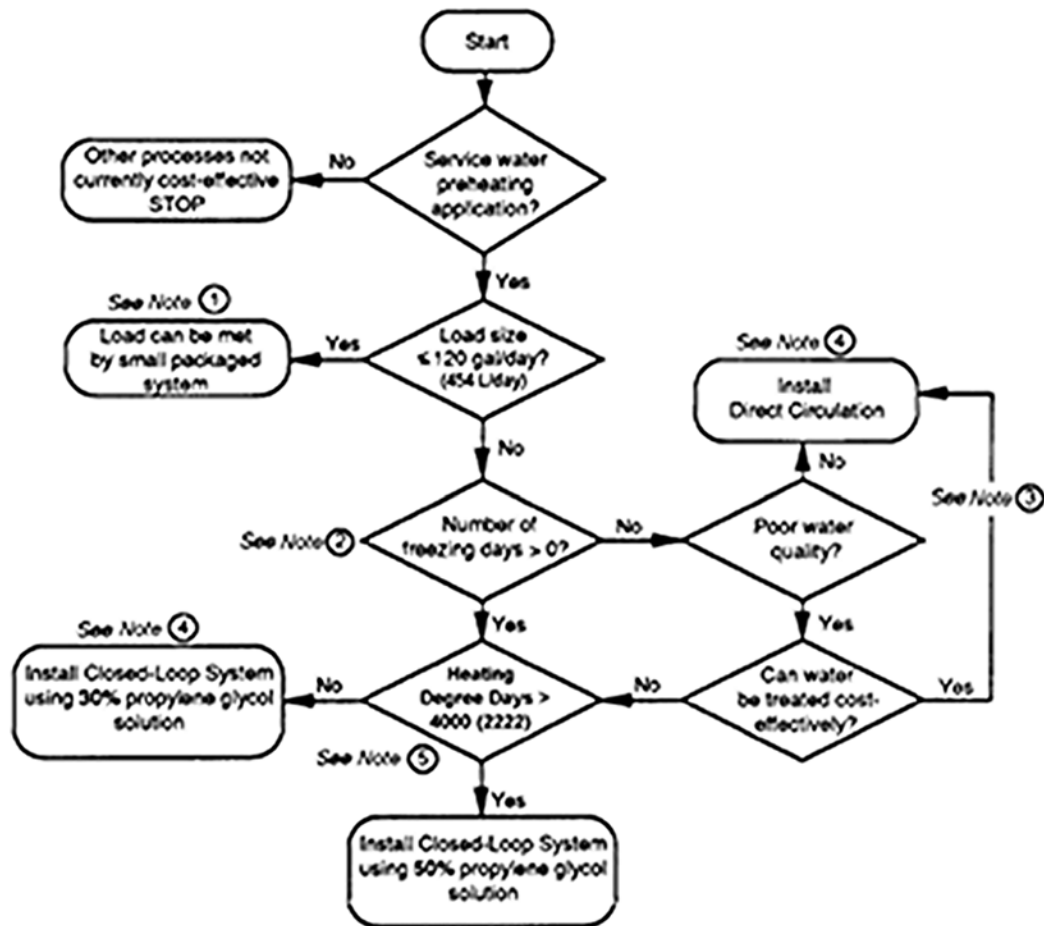
Figure 3-3

System selection flow chart

Figure 3-3 Notes: Notes keyed into the flowchart are listed below by corresponding number.

1. For small loads on the order of a residential-sized service water heating system, the design effort and expense can be avoided by purchasing a pre-designed "packaged" system from a reliable manufacturer. These systems are sold in a variety of configurations, including drainback and closed-loop.

2. The number of freezing days at the site should be determined, based on recorded historical data. To meet the "no freezing day" criterion, there should be no evidence of freezing temperatures for a period approximately equal to the expected lifetime of the system. Existing data shows that no location in the continental U.S. can meet this criterion. Historical weather data can be obtained from the local National Weather Bureau stations or from the Environmental Data Service, a branch of the U.S. Department of Commerce.

3. Water quality should be determined using appropriate resources.

4. Systems larger than 3,000 ft2 (279 m2) will require very large piping (4-inch (100 mm) diameter or larger) and roof area, and are not recommended. If this situation occurs, the designer should consider installing two separate systems. Although this approach is somewhat more costly, it improves the ease of construction and allows solar energy to be collected in the event of one system being down due to

maintenance or repair. The decision to use separate systems depends on specific project parameters and is left to the designer.

5. Both the Fahrenheit (F) and Celsius (C) based versions of heating degree days are presented (the Celsius based number is in parentheses). Heating degree days are based on the mean annual number of degree days using a base of 65 degrees F (18 degrees C). Only 30 to 50 percent volume propylene glycol/water solutions can be used in closed-loop systems. Locations requiring a closed-loop system that has less than 4,000 (2222) heating degree-days per year may use the 30 percent solution; those having more heating degree days should use a 50 percent solution. This heating day criteria is provided as a suggested guideline only. It is up to the designer to take into account each location's particular climate and freezing-day characteristics when determining whether a 30 or 50 percent solution should be used.

3.4 SYSTEM LAYOUT. The system layout phase identifies the solar energy system requirements that will impose certain constraints on the building design. The architect and structural engineer must be notified of these requirements early in the design stage of the project. These requirements include proper orientation of the building, identification of available roof area and structural criteria, and proper design and location of the equipment room. Once these requirements are met and the necessary building parameters are fixed, the solar system design can be completed.

3.4.1 COLLECTOR SUB-SYSTEM

3.4.1.1 REPRESENTATIVE SOLAR COLLECTORS. Many flat-plate solar collector (refer to Figure 3-4) sizes are available. Typical collectors range in size from about 16 to 47 ft^2 (1.5 to 4.4 m^2) of net aperture area, with corresponding gross dimensions of 3 by 6 ft (914 by 1829 mm), to 4 by 13 ft (1219 by 3962 mm). Two standard sizes are considered to be about 30 and 40 ft^2 (2.8 and 3.7 m^2), with gross dimensions of 4 by 8 ft (1219 by 2348 mm) and 4 by 10 ft (1219 by 3048 mm), respectively. Single-glazed collectors filled with liquid weigh approximately 4 to 5 lbs/ ft^2 (192 to 239 Pa). Recommended flow rates vary over a wide range, but most fall between 0.01 to 0.05 gals/min-ft^2 (0.007 to 0.034 L/sec-m^2).
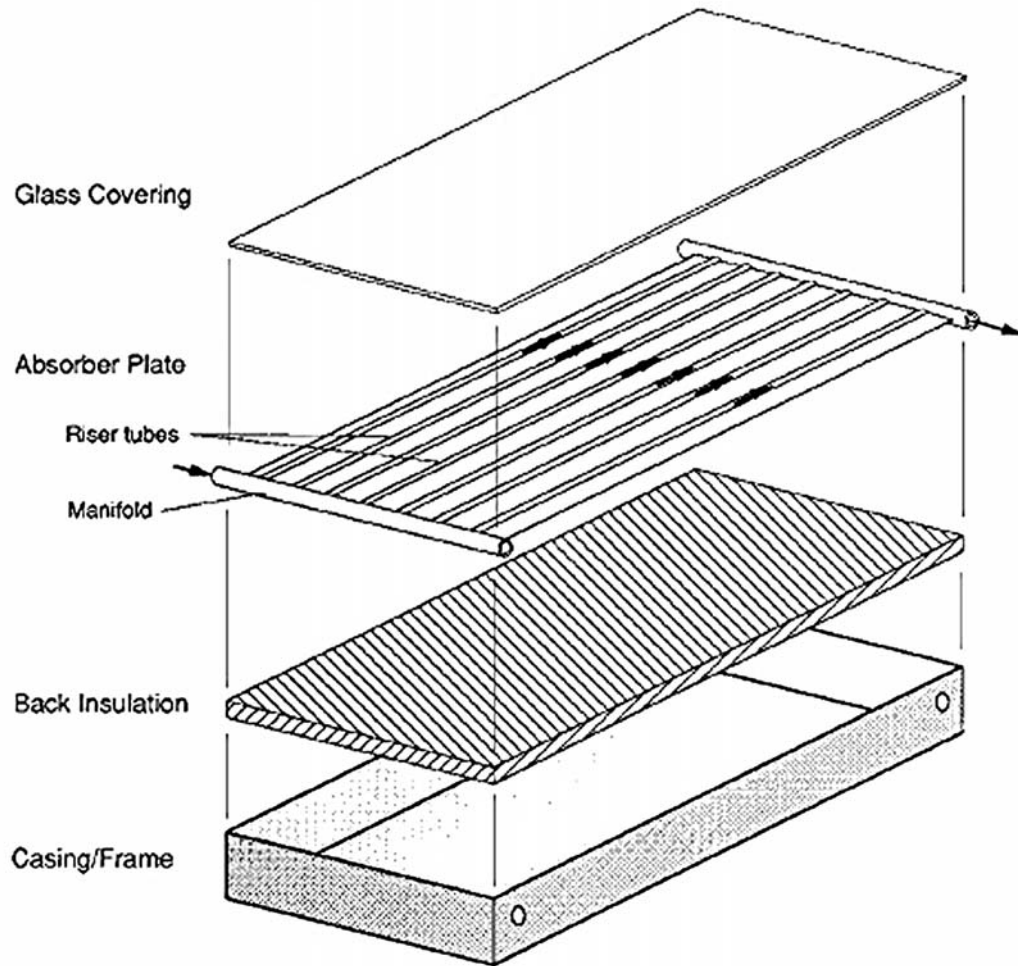
Figure 3-4

Flat-plate collector

3.4.1.2 ARRAY SIZE. The first step in the system layout is to estimate collector array size (the actual array size cannot be determined until a specific collector is chosen for the detailed design).

3.4.1.3 ARRAY TILT ANGLE. The collector array tilt angle is defined to be the angle between the collector and the horizontal, with 0 degrees being horizontal and 90 degrees being vertical. The proper tilt angle is a function of the time of year when the load occurs. For annual loads, such as service and process water heating, the widely accepted practice is to tilt the collectors to the value of the local latitude. If the load tends to have a seasonal variation, the tilt can be varied to favor the season. Examples

include seasonal hot water requirements, space heating, and space cooling. If the collectors are tilted to the latitude angle plus 10 degrees, the energy output will be more evenly distributed over the entire year, although winter losses will tend to increase, due to lower outdoor temperatures. Tilting the array to the latitude minus 10 degrees favors summer energy output. It is not generally recommended to tilt the array any more than plus or minus 10 degrees from the site latitude. It should be noted that as the tilt angle increases, the minimum spacing between rows due to shading increases and a larger roof area is required.

3.4.1.4 ARRAY AZIMUTH ANGLE. The array azimuth angle is defined to be the angle between the projection of the normal to the surface on a horizontal plane and the local meridian (north-south line). Zero degrees is defined as due south, a due west facing array is defined as plus 90 degrees, and a due east facing array is defined as minus 90 degrees (in the northern hemisphere). The optimal orientation requires the azimuth angle to be 0 degrees (due south) whenever possible, although deviations of plus or minus 20 degrees off of due south have a minimal effect on flat-plate system performance.

3.4.1.5 COLLECTOR GROUPING. Internal-manifold collectors should be grouped into banks ranging from four to seven collectors each, with each bank containing the same number of collectors. Proper sizing of the collector banks is essential to maintaining uniform flow throughout the collector array. The maximum number of collectors that can be banked together is a function of the maximum flow rate allowed in the plumbing, internal manifold and riser diameters, thermal expansion characteristics of the collector piping and absorber plate assembly, and the recommended flow rate of the particular collector chosen (usually given in gallons per minute (liters per second) per collector or gallons per minute per square feet (liters per second per square meter) of collector area). Thermal expansion problems are minimized by keeping the bank size less than eight collectors**.**

3-4.1.6 MINIMUM ARRAY ROW SPACING. The minimum row spacing must be calculated for multi-row arrays. A general routine for north-south spacing of collector banks can be devised, based on a "no shading" criterion for a particular time of year. The guidance presented assumes no shading of the array on the "worst" solar day of the year (21 December, when the sun is lowest in the sky in the northern hemisphere) for the designated time period of 10 a.m. to 2 p.m. solar time. Most large-scale military solar systems are installed on low-slope flat roofs, and there are two possible cases to consider. The first is for a flat roof with enough space to locate the collector array at one elevation. The second case is for a flat roof with too little space for the collector array. This requires the collector banks to be "stepped", that is, each succeeding row of collectors must be elevated. This arrangement is necessary if the collector roof area required is larger than that available or if roof area costs are more expensive than elevated rack costs. The equations developed for minimum collector row spacing are presented graphically in Figure 3-5.
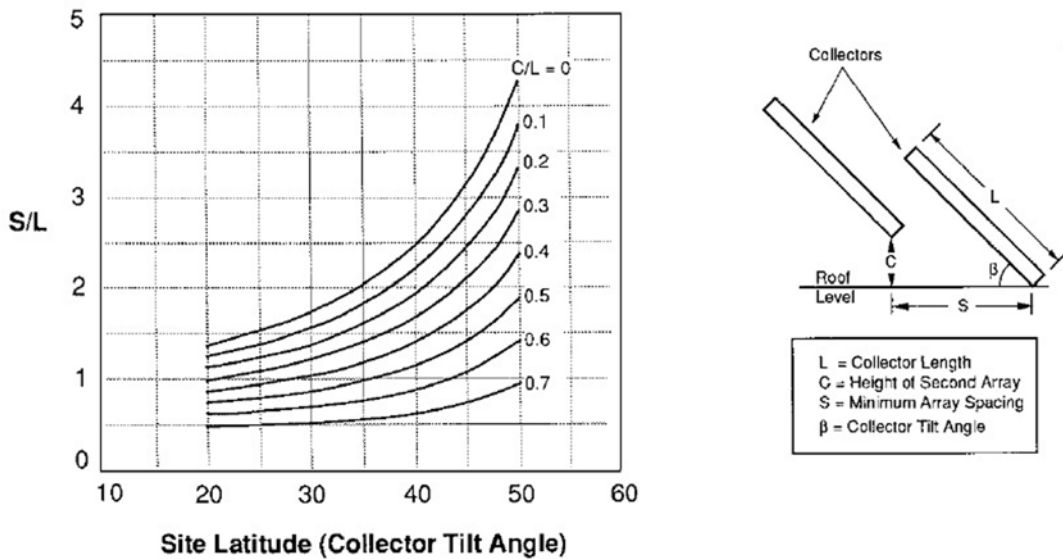

Figure 3-5

Minimum collector row spacing

3.4.1.6.1 AZIMUTH ORIENTATIONS. The curves shown in Figure 3-5 are for collector azimuth orientations of plus or minus 20 degrees. For the due south orientation (0 degrees), the deviation from these results is less than 10%. Use of Figure 3-5 for due south orientations is thus slightly conservative. The effect of elevating the rear collector row (larger C/L values) shows a marked decrease in the minimum spacing (S/L). For a flat roof, no elevation collector case is represented by the curves where C/L = 0.

3.4.1.6.2 ROOF PITCH. Collectors can also be mounted on pitched roofs. Often, when a solar energy system is to be added to a building, the roof is pitched and constructed such that the collectors could be mounted on the roof surface. This practice does not necessarily impose unreasonable constraints in the roof design, since there is some flexibility in the choice of collector tilt angle. If the roof cannot be pitched to allow flush mounting of the collectors, or if the tilt angle must be fixed, then the collectors can be raised at one end to give them the proper tilt. Figure 3-5 can be used to determine the spacing by including the appropriate roof pitch with the height C.

3.4.1.6.3 ARRAY LAYOUTS AND ESTIMATED ROOF AREA OPTIONS. Collector array layouts and estimated roof area requirements for the system can be determined by using the estimated array size. For example, assume that 818 ft2 (76 m2) of collector area is required for a project located at 40 degrees N latitude. The number of collectors to install can be determined by dividing the calculated array area by the net aperture area of the collector. If a 4 by 8 foot (1219 by 2438 mm) collector with 31 ft2 (2.9 m2) of net aperture area is to be used, the calculation results in 26.4 collectors. Since 26 collectors cannot be divided evenly into banks of four, five, six, or seven, the designer must deviate from the calculated value by rounding to the next highest possibility result (i.e., 28 collectors). These units can be grouped into four banks of seven collectors or seven banks of four collectors each. The length required for the collector banks is the width of the collectors plus connective piping. It is conservative to estimate 6 inches (152 mm) of connective piping between collectors, 3 ft (914 mm) between banks in the lateral dimension, and 4 ft (1219 mm) around the banks for personnel clearance. The bank widths are then estimated to be 31 ft (9449 mm) for the seven-collector bank and

17.5 ft (5334 mm) for the four-collector bank. The distance required between collector rows can be found from Figure 3-5. For example, an 8 ft (2438 mm) collector at 40 degrees N latitude requires row spacing of about 2.5 times 8 ft (2438 mm), or 20 ft (6096 mm). The array layout should be determined by keeping in mind that the piping length should be minimized while geometric symmetry is maintained. This guidance results in a tendency for the banks to contain as many collectors as possible, and for the array layout to be rectangular in area with an even number of banks installed in multiple rows. Therefore, the case of four banks with seven collectors each is the most preferred. A number of roof area dimensions should be proposed so the architect has some flexibility in determining the building orientation and dimensions. Figure 3-6 shows three possible collector array layouts for the 28-collector array. Similar consideration can be given to the use of a 4 by 10 ft (1219 by 3048 mm) collector. The result would be 21 collectors (possibly rounded to 24 or 20), 25 ft (7620 mm) row spacing (if needed), and banks of seven, six, or five collectors respectively.
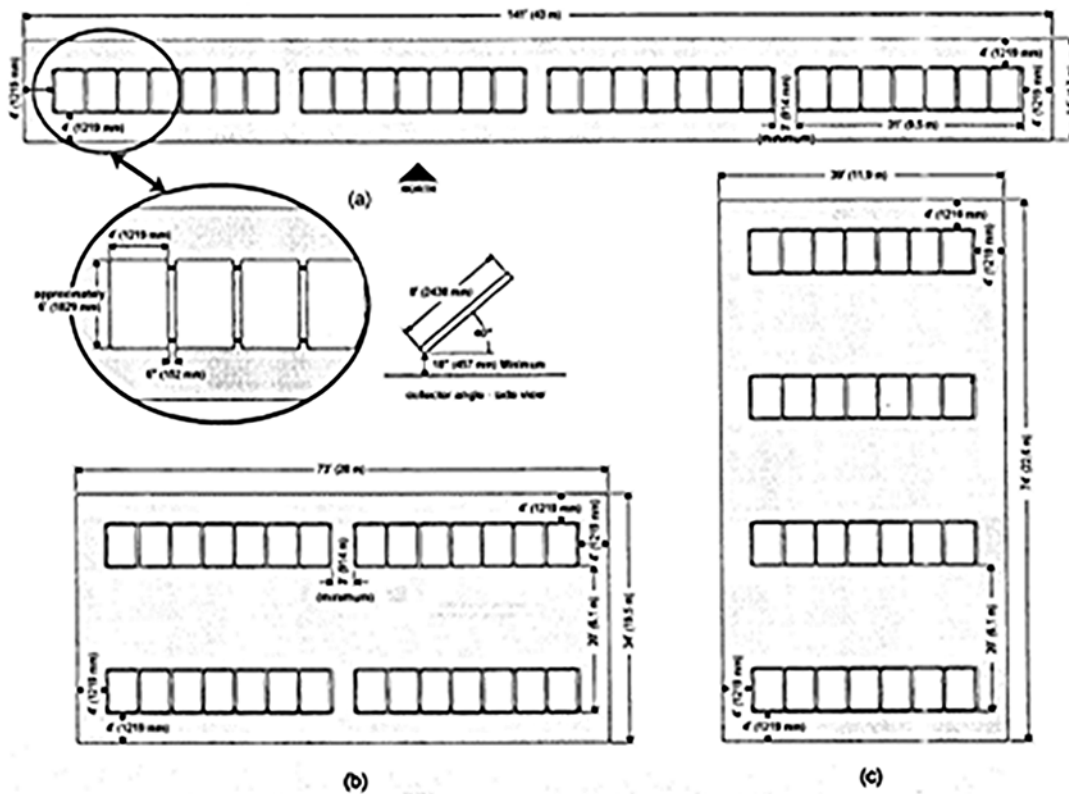

Figure 3-6

Possible array configurations and areas

3.4.1.7 ARRAY SUPPORT STRUCTURE. The support structure must transmit the various loads incident upon the array to the building roof structure without overstressing it. The design must meet all code requirements and should be coordinated with, or reviewed by, a qualified structural engineer. At the system layout stage, the structural engineer or architect should have an idea about the building and roof type before the support structure is planned. Although steel has often been used for array structures, all systems designed under this guidance will be made from aluminum, to avoid the cost of applying and maintaining a protective finish. Although it is difficult to generalize, experience has yielded some useful estimates about the weight and cost of large collector support structures. As a rough guideline for rack-type structures, the weight of the structure should be less than 5 lbs/ ft² (239 Pa) of collector area. The cost of the support structure typically represents less than 15 to 20 percent of the total solar system cost. Any support structures falling outside of these guidelines could be considered inefficient from a cost versus performance view. It is expected that the support structure may be heavier and more costly in areas where design loads are higher or where stepped collector rows are required. Further, stepped arrays require elevated walkways for maintenance personnel, which results in higher material and design costs.

3.4.2 STORAGE SUB-SYSTEM

3.4.2.1 STORAGE TANK SIZE. At the system layout stage, the storage tank volume and dimensions have a major impact on the design and location of the equipment room. Selection or specification of the storage tank requires first determining the appropriate volume of the tank. The widely accepted practice for service water heating applications is to provide a storage tank volume of 1.5 to 2 gals per square foot (61.1 to 81.5 L per square meter) of collector area. Storage systems larger than this do not significantly increase the performance of the solar system, and the additional costs associated with larger storage are not justified. Storage systems smaller than this size can decrease system performance. The lower performance is due to relatively high storage temperatures, resulting in lower solar collector efficiencies. Within these guidelines, the exact size of the storage tank is not critical to system performance and should be based

upon available standard sizes. To provide proper stratification and to meet space requirements, vertical storage tanks are preferred. As tank size increases, space considerations and floor area become increasingly critical. When it becomes apparent that a single vertical tank is not possible, a horizontal tank or a series of vertical tanks will be necessary.

3.4.2.2 STORAGE TANK LOCATION

3.4.2.2.1 INDOOR VERSUS OUTDOOR. As with conventional energy systems, a solar system requires an equipment room to contain the heat exchanger, pumps, control system, and associated plumbing. If possible, the equipment room should be designed to house the solar storage tank. For retrofit situations where existing space does not permit the required tank volume, an outdoor location may be chosen. However, many factors discourage the location of storage tanks outside the building, such as a higher annual standby energy loss (in most climates) and adverse environmental effects on the tank (including ultraviolet and moisture-based degradation). Solar storage tanks are not to be located underground. Underground tanks have had numerous problems, including leakage due to tank and ground shifting and thermal stresses; corrosion due to the lack of cathodic protection; tanks surfacing due to buoyant forces while empty; and difficulty in retrieving and repairing sensors and instruments.

3.4.2.2.2 TANK SUPPORT AND FLOOR LOADS. Reinforced concrete pads and footings are often required to ensure that the weight of the tank does not endanger the structural integrity of the building. The design load calculation should take into account the estimated weight of the empty tank, the water to be stored in the tank, the insulation, and the tank support structure. The design load for the footing is also dependent on the type of tank support used.

3.4.2.3 LEGIONNAIRE'S DISEASE. If a direct circulating system is supplying water for domestic use, ensure that water in the storage tank is heated to a minimum of 140

degrees F (60 degrees C) in order to avoid any potential source of Legionnaire's disease.

3.4.3   TRANSPORT SUB-SYSTEM.   To ensure that the transport sub-system is properly accounted for in the building design, space must be provided in the equipment room for the heat exchanger, expansion tank, pumps, and system plumbing, in addition to the storage tank and control system. Pipe chases are also required between the equipment room and the space on the roof where the system will be located.

3.4.4 CONTROL SUB-SYSTEM

3.4.4.1   CONTROL STRATEGY.   For the control strategy, the designer must specify operating modes and freeze/over-temperature protection methods. It should be noted that the control strategy presented for the standard closed-loop system is intended to be simple, reliable, and built with off-the-shelf components.

3.4.4.1.1   PUMP ACTIVATION.   Using the differential temperature controller, the collector and storage loop pumps should be energized whenever the difference between the absorber plate and storage tank temperatures is greater than some high set point differential temperature T_H, typically 15 to 25 degrees F (8 to 14 degrees C). The pumps should stay on until that temperature difference is less than some low setpoint differential temperature T_L, usually between 5 to 8 degrees F (3 to 4 degrees).

3.4.4.1.2   FREEZE PROTECTION.   The propylene glycol mixture used in the closed-loop system provides freeze protection. Direct circulation is used only in non-freezing climates. Because the direct circulation system is more or less a special type of closedloop system, its control strategy is the same.

3.4.4.1.3   OVER-TEMPERATURE PROTECTION.   Over-temperature protection of the collector loop in the event of stagnation is provided through expansion tank sizing. The pressure-temperature relief valve located on the storage tank supplies over-temperature

protection of the storage loop. If a direct circulating system is supplying water for domestic use, it is required that users be protected against the possibility of live steam being issued from taps or showerheads. This protection is provided through the proper use of relief and mixing valves.

3.4.4.1.4 AUXILIARY PUMP SWITCHES. The use of auxiliary high- and low temperature switches that will trip the pumps as a backup to the differential controller are not recommended. These switches are as prone to failure as the controller, and have been the cause of many solar system failures.

3.4.4.2 LOCATION OF CONTROLS. Whenever possible, electronic displays and visual pressure and temperature gauges should be panel-mounted together in the mechanical room. Temperature sensors, which are located on the collector manifolds and on the storage tank, should be easily accessible for calibration and servicing. A common problem is sources of electromagnetic interference with the sensor wiring. This problem can be avoided by making the sensor wiring path as short as possible and by using a conduit separate from AC power wiring. It may be desirable to include extra conductors for future expansion or maintenance needs.

3.5 COORDINATION. The system designer is responsible for ensuring that all essential information is provided to the architect and structural engineer, so that the building plan can accommodate the solar system requirements.

3.5.1 ARCHITECT

3.5.1.1 ROOF REQUIREMENTS. The most important requirement for the architect, with regard to the solar energy system, is to provide adequate unshaded roof area and proper orientation for the system. Other architectural requirements for roof design include providing roof penetrations near the array for collector supply and return lines; designing the array support structure; allowing adequate access to the array for maintenance; including access to the roof for personnel (and equipment); including

walkways around the array; and locating the collector array above or near an area that can be used for pipe chases.

3.5.1.2 EQUIPMENT ROOM

3.5.1.2.1 LOCATION. The equipment room for the solar energy system hardware will be configured to allow easy access by operation and maintenance (O&M) personnel. The designer will minimize piping distances, both to the array and to the load.

3.5.1.2.2 DESIGN. Whenever possible, the solar system equipment room will house solar storage tank, heat exchanger, expansion tank, pumps, control system, and related plumbing. The backup heating system will also be located in the equipment room. The room will be sized to allow O&M personnel to move about freely and replace equipment as necessary. A floor drain will be provided near the storage tank relief valve. Control panels will be installed in easily accessible areas and will be clearly visible.

3.5.2 STRUCTURAL ENGINEER

3.5.2.1 ARRAY SUPPORT SYSTEM. The structural engineer (or project designer, if qualified) is responsible for the design of the array support structure once the architect has decided on a roof type. This step includes deciding if a flush roof-mounted or elevated rack-type support will be used and the type of materials and finish to be considered for the structure.

3.5.2.2 ROOF LOADING. The roof loads due to the array are point loads, and depend on the collector array layout and the type of array support structure used. By knowing the array layout (the width, length, and approximate spacing of the array) and the proposed roof design and array support structure, the structural engineer and architect can determine the best proposed roof support mechanism.