Designing and Installing Solar Commercial Pool Heating Systems

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CHAPTER 1

INTRODUCTION

Solar heating of swimming pools is an economically attractive utiliza- of Florida's abundant solar resource The temperature requirement is lower than that for domestic or service water heating, lower than that for building heating and far lower than that for solar powered air conditioning Florida's year-round mild and sunny climate allows swimming during much of the winter, so a properly heated pool is economically attractive

Because the difference between ambient air temperature and desired pool temperature is comparatively low, relatively inexpensive unglazed solar collectors can effectively heat swimming pools However, in commercial pool heating applications, glazed collectors may be justified This can be determined through calculating the heating load and solar system output based on average weather conditions at the pool site. In some cases, the higher initial cost of an array of glazed collectors is offset by future fuel savings.

The design and installation of solar swimming pool heaters can be aptly described as more art than science Many of the design calculations require the input of data that is subjectively judged to be appropriate by the designer. For example 1) wind speed over the surface of the pool greatly affects evaporation and convection losses. These in turn are major contributors to the total heat loss. Heat loss determines the load that a heater of any kind must meet Micro-climatic conditions, the location of man-made structures, and inconsistancies in seasonal weather variations make it difficult to select appropriate wind speed data and to accurately calculate the heating load

2) Unglazed solar collecting surfaces are tested in accordance with ASHRAE 96-80 Thermal Test procedure. They are rated by FSEC in terms of their calculated performance during a "standard Florida day" -- 1600 Btu/ft^2, 81°F average air temperature and 95°F average solar collector temperature However, when pool heating is required in Florida the air temperature may be well below 81°F, the average collector temperature may be below 95°F, and the insolation rate may be above or below 1600 Btu/ft^2 day. Additionally, the performance of unglazed collectors is substantially reduced by cold winds blowing across their surfaces. Their performance equations, graphs and low-temperature ratings do not disclose this fact because the ASHRAE 96-80 test procedure is conducted at wind speeds of less than 3 mph. 3) Swimming pools which are not shaded from about 4 hours before until 4 hours after solar noon pick up 1000 to 1500 Btu/ft^2 of pool area each day by direct absorption of the sunshine which falls on their surfaces Yet a screen room reduces that gain by 30-40%. These facts introduce uncertainties in evaluating the output which may be expected of an array of solar collectors. Thus, a working knowledge of their effect is critical to sound system design.

This design manual attempts to address these and other peculiarities of solar swimming pool and spa heating and presents methods for quantifying losses, gains, solar collector contribution and system performance Simplified collector rating methods (nomographs and tables) that are reasonably accurate are presented for the first time in an FSEC publication Graphical aids which enable the designer to convert weather station wind data to specific airflow rates on top of or in the vicinity of a variety of sizes and shapes of buildings are included text is divided into chapters on load evaluation, energy conservation techniques, commonly used piping configurations flow control and freeze protection strategies, the effect of solar intensity and air temperature on collector efficiency, the effect of wind speed on unglazed collector output, array sizing methods, pump, piping and filter sizing and accepable installation practices.

Appendixes include a number of nomographs which simplify the required engineering calculations and an explanation of the derivation of the methodology suggested in the text, calculation of air flow rates over both the pool and collector surfaces, and weather data. The weather data presented is for Florida cities only but such data is available for cities in other states from the National Oceanic and Atmospheric Administration The address of that organization is given on page C-7

Illustrative problems have been included where it was felt they would clarify critical design concepts. Because this manual is specifically written for trained professionals, theoretical treatment of the various aspects of solar pool heating is limited to the minimum required for their understanding of the processes described Those interested in more indepth descriptions of solar pool and spa heating theory are referred to other FSEC publications (especially "Solar Water Heating and Pool Heating Manual") and "Solar Heating for Swimming Pools," which is available from the Environmental Information Center (EIC), Winter Park, Florida

Some elements of this manual appear in other Florida Solar Energy Center (FSEC) publications, some are adapted from "Solar Heating for Swimming Pools" published by EIC, and many appear for the first time in this publication

SUMMARY OF DESIGN PROCEDURE

The following design procedure includes chapter and in some cases references to detailed methodology Options for some steps are suggested in decreasing order of desirability

Step 1 Determine the pool heating load for each month during which heating may be required by:

A Using historical energy consumption records if they are available Refer to pages 2-1 to 2-3

B Using FSEC tabulated heat loss factors for various pool configurations in six representative Florida cities Refer to pages G-1 to G-8

C. Performing heat loss calculations based on accepted heat and mass transfer formulas. Refer to page 2-4 to 2-16

2 Determine the monthly contribution which may be expected from a specific collector(s)(it varies from month to month) Do this by

A Using the predicted daily output of the collector(s) as determined by FSEC calculator or computer programs. Refer to Appendix F Pages F-1 to F-11

B Using the predicted daily output of the collector(s) as determined from FSEC nomographs Refer to appendix A pages A-1 to A-18 and pages 5-9 to 5-13 in the main body of the text.

The required temperature and insolation data appears on pages E-1 to E-13

3 As a first approximation, size a collector array based on 80% of the January heat losses from the swimming pool and the January output of the collector(s) under consideration

Collector area (ft^2) =

$$\frac{.8 \times \text{January loss (MM Btu/mo per 100 } ft^2) \times \text{Pool Area } (ft^2)/100}{\text{Collector Output } (\text{Btu/day} \cdot ft^2) \times 31 \text{ days}/1{,}000{,}000}$$

Step 4 Select a system penalty factor Increase the collector area to compensate for the system penalty which has been selected.

$$\frac{\text{Collector area } (ft^2)}{\text{Penalty factor}} = \text{Corrected Collector area } (ft^2)$$

Refer to page 5-16

5: Determine the load (monthly pool losses) for each month during which pool heating is required. As a rule of thumb, some heating will be required to maintain an unshaded, unscreened pool at 78°F if the average (24 hour) air temperature for the month is less than 75°F.

Step 6: Determine monthly the output of the <u>corrected</u> collector area for the temperature and insolation conditions for each of the months during which pool heating is required. Then apply the system penalty to determine the monthly system output.

Step 7 Determine the annual energy and fuel cost savings based on the <u>lessor</u> of monthly load or monthly solar system output

Step 8 Estimate the solar system cost (including pumps, controllers etc.) and calculate return on investment (based on current or projected energy cost information).

$$\frac{\text{Annual fuel costs saved x 100}}{\text{System cost}} = \text{\% return}$$

Step 9: By repeating the above eight steps for, say, 60, 70, 80, 90 and 100 percent of the January load, an array size which yields the best return on initial investment may be determined