SOLAR BUILDINGS

Solar Water Heaters
The Next Generation

THE U.S. DEPARTMENT OF ENERGY IS PURSUING AN AGGRESSIVE GOAL TO CUT THE COST OF SOLAR WATER-HEATING SYSTEMS IN HALF. REPLACING METAL AND GLASS COMPONENTS WITH LESS-EXPENSIVE PLASTIC ONES IS A KEY STRATEGY FOR THAT GOAL.

Solar water heating is a well-established, highly effective, pollution-free technology for domestic water heating that can be used throughout the country. More than one million homes and businesses in the United States have been equipped to use water heated by the sun. Twenty-nine U.S. manufacturers shipped solar thermal collectors in 1999. Is there any reason why everyone is not installing solar collectors?

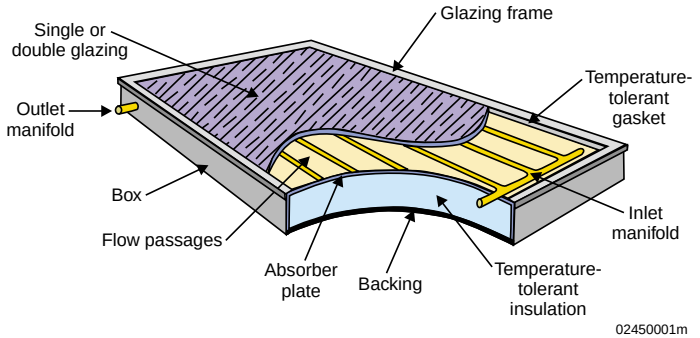
Until recently, in most parts of the country, natural gas or other inexpensive water heating cost so little that it may have taken many years for the savings resulting from solar water heating to repay the initial cost of the system. Recent increases in the cost of natural gas make it clear that the need for clean energy for water heating remains strong. A significant amount of energy is used for water heating—indeed, water heating accounts for 18% of the energy used in the U.S. residential sector. And more and more systems are being installed as new buildings are constructed and as existing systems are replaced, underscoring the need for renewable options. Yet, solar collector sales in recent years have actually been dominated by less-expensive, lower-temperature systems used mostly for swimming pool heating.

Taking a page from the book of the pool-heating collectors—which are made almost totally from plastic—the U.S. Department of Energy's (DOE's) Solar Buildings Program is researching ways to replace with less-expensive materials the metal and glass now used to make medium-temperature collectors for domestic water heating. During 2000, the National Renewable Energy Laboratory (NREL), DOE's renewable energy specialist, Sandia National Laboratories, and the solar industry worked on several studies on the use of plastics in solar water heaters. Laboratory researchers are also doing related material research and durability testing.

Building with Polymers

Laboratory researchers and other experts see great potential for constructing solar water-heating systems with polymer materials (giant molecules formed from chains of simpler molecules). Polymers could replace or reduce the need for glass, copper, and steel in the collectors and the piping. The material and manufacturing cost per unit area is much lower for polymers, so manufacturing costs could be significantly reduced. They also weigh less, which reduces the cost of shipping, handling, and installation.

The successful use of polymers in solar applications requires overcoming two engineering challenges: (1) the thermal conductance of polymers is much lower than that of metals, which can reduce water-heating performance; and (2) not all polymers weather



This typical flat-plate solar-collector design uses glass glazing, copper tubing, aluminum frame, and quality insulation. Substituting plastic for some of these components could lead to a new generation of low-cost solar water heaters.

well in the sun—some early commercial and experimental solar systems built during the late 1970s and early 1980s experienced discoloration and failure due to exposure to ultraviolet (UV) solar radiation.

Lower thermal conductances can be largely accommodated with designs that place the heat-transfer fluid in direct contact with the absorber—rather than indirectly, such as through the use of fins. In addition, the polymer industry is developing new polymer materials manufactured with chemical additives that result in higher thermal conductances and protection from UV radiation. In October 1997, program researchers held a workshop attended by members of both the polymer and solar industries to investigate the practicability of building solar systems with these new polymers. This led, during 1998, to the formation of a collaborative effort between representatives of DOE and these two industries to exchange information and to coordinate research and development.

Industry-Laboratory Collaboration

In 1999, six solar industry partners developed concepts of potentially low-cost systems that used polymers. The two most promising concepts were selected for further research and development in 2000. Both industry-proposed concepts are passive solar water-heating designs that are suitable for mild Sunbelt climates. Laboratory and university researchers modeled and optimized the new systems, characterized the systems' performance, and tested candidate polymers for durability, thereby providing assistance to industry. Prototype systems are scheduled to be constructed and tested in 2001, with field testing of "second-generation" prototypes beginning in 2002.

Materials durability remains an important issue. Accelerated durability testing will continue, including use of weathering chambers and ultra-accelerated UV tests. In the chamber tests, a number of domestic and European glazing samples claimed to be suitable for outdoor use by suppliers were put to the test. Many of the samples supplied have shown unacceptable yellowing in the weathering chambers after five years of equivalent exposure at 140°F (60°C). However, these same materials have shown no detectable loss of transmission or yellowing when protected with an additional UV-resistant coating. These and other time-accelerated studies are invaluable for reducing the risk of fielding new products.

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This testing chamber subjects polymer-glazing samples to UV light carefully matched to the natural light spectrum. The incident radiation upon the samples is twice the normal intensity and is operated 24 hours per day, resulting in about six times the acceleration of normal exposure. Temperature and humidity are also controlled during testing.

Molding the Future

NREL, Sandia, and their industry partners are exploring the use of plastic heat exchangers, thin-film plastic absorbers and glazings, plastic collectors, and plastic storage vessels. If results from the field trials of these systems are promising, the work will be continued toward final product development and manufacturing. These studies will likely also suggest other ways that polymers could be used to lower the cost of solar water heater manufacture and installation, including the development of low-cost collectors and storage for hard-freeze climates. Whether through the use of polymers, installation efficiencies, or some other means, the Solar Buildings Program aims to reduce by 50% the installation and hardware costs of solar water heaters by 2005. As the Solar Buildings Program meets the technological challenges necessary to achieve this goal, solar energy will play an increasing role in heating water in the buildings sector.

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