Solar Pool Heating

Basics, Part 1

Tom Lane

Using the sun for more "fun in the sun"—a solar heated pool extends your swimming season with no energy costs.

The primary reasons that we own pools are for family fun, pleasure at home with friends, a healthy and relaxed environment, exercise, and stress relief. A heated pool lengthens the swimming season and becomes a pool that gets used.

Solar pool heating systems are easy, economical, and environmentally friendly. Solar pool heating is perhaps the most cost-effective application of solar energy under the sun. Over 10 million square feet of solar pool collectors were installed for about 33,000 pools in 2001—up 25 percent from 1999. People are catching on that solar pool heating makes good sense.

Solar pool heating systems have distinct differences from the domestic solar water heating applications covered in previous issues of *Home Power*. The larger volume of water, lower temperature requirements, and seasonal use pattern are significantly different design parameters that result in a simpler solar collector at lower unit cost and higher efficiency.

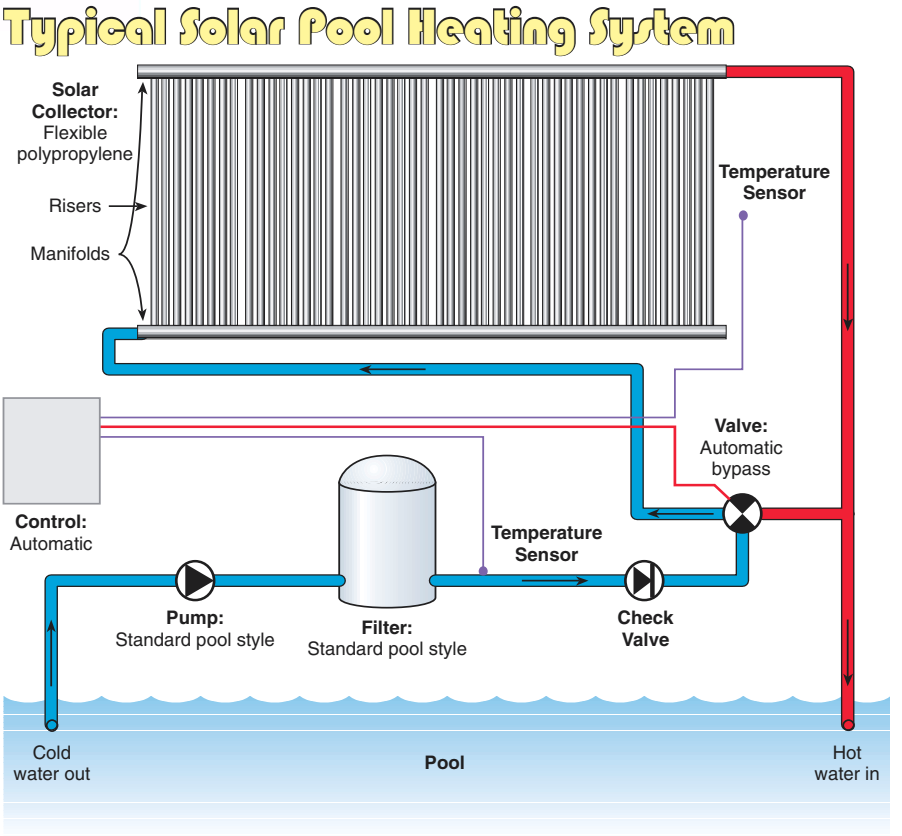
This two-part article will help you extend your pool's comfort season. Part 1 of this article will help owners of residential-sized swimming pools understand how simple, easy, and cost effective solar pool heating is. In addition, basic system components and their functions will be described. Part 2 will discuss the nuts and bolts of sizing solar pool heaters, collector orientation and mounting, installation recommendations, and commercial applications. An extensive list of suppliers is included in the Access section.

Solar pool panels—roof mounted.

Extend the Swimming Season

The solar pool heating season can extend from the last freeze in the spring until the first freeze in the fall. For most people in the United States, an acceptable pool heating season may range from 4 to 6 months long. Only in Hawaii, central and southern Florida, and parts of southern California and Arizona does most of the population expect to swim all year long. In all cases, the relative temperature increase from a solar pool heater over that of an unheated pool will be about the same.

As a crude guideline for comfort, you can expect solar pool heating systems to meet your expectations for swimming during months in which you are comfortable outside, day or night, without wearing a sweater or coat. For months in which you wear a sweater or coat for comfort during the day, you will need a removable pool cover and a backup heater.



Anatomy & Operation

A solar pool heating system consists of a solar pool collector, automatic control, diverter valve, and associated piping. These components typically work with the pool's existing pump and filter. A backup heater may be incorporated into the system design as well. A pool cover or blanket is a good energy conservation feature to extend the season and to maintain a higher pool temperature.

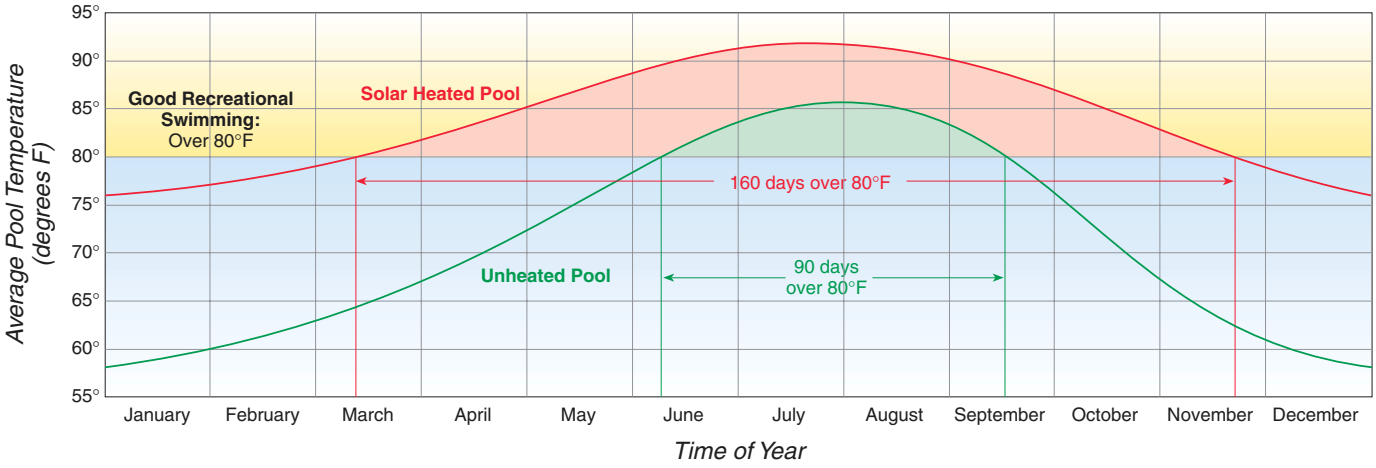
The typical solar pool heating system is an open loop, drainback design. Pool water is circulated directly through the collectors when the pool's standard circulation pump is activated. When the pump turns off, the water in the collectors drains back into the pool. A vacuum breaker opens to let air in at the top of the collector. This allows the collectors to drain completely. When the system starts up the next day, it will blow air out of the return lines for a while before the water starts returning from the top of the pool collectors.

Pool pumps are used to filter pool water and are operated on a timer. When used with a solar heating system, the timer is typically set from 9 AM to 4 PM to filter the pool while collecting solar heat. An existing 1 horsepower pool pump can easily circulate the water through solar pool collectors.

An automatic solar controller, called a differential controller, allows you to set the high temperature limit to your comfort level. It is similar to the control used in a solar domestic water heater. It compares the water temperatures measured at the solar collector and the pool. If the collector temperature is at least 4°F (2.2°C) higher than the pool water and the pool is below the desired set point temperature, the control opens the diverter valve. This allows circulation of pool water to the collector and back if the pump is on. A diverter valve in the system either sends the water through the solar collector or straight back to the pool from the pump.

Solar pool panels—ground mounted.

Example Increase of Swimming Season Using Solar Heating: North Florida



Conditions: 20-year average weather data for North Florida. 1,000 BTU per square foot per day of collector output for a pool in full sunlight; a screened-in pool would typically be 5°F lower year-round. Pool blanket used when night-time temperatures are below 60°F.

During midsummer, if the pool is getting too hot, the pool pump may be operated at night by changing the set points of the controls to use the collectors in reverse to cool the pool water. This strategy is often used with lap pools where a lower temperature can be desirable.

The components of a solar pool heating system—you may aready have many of them.

Solar Pool Collectors

The main piece of equipment involved in solar pool heating is the solar collector. Collectors for pool heating are different than those used for solar domestic hot water. Most solar pool collectors use an unglazed, plastic, flat plate collector, with no insulated box. The collectors can be mounted on the ground or a nearby roof.

A solar pool heating collector is very simple. The absorber plate is the black surface of the collector, which, like any dark surface in the sun, converts solar radiant energy into heat. The liquid to be heated passes through the risers, which are parallel tubes integrated into the absorber plate. The risers are connected at each end by manifolds, which serve as the collector's inlet and outlet pipes.

Pool collectors are made from EPDM rubber, copolymers, or polypropylene. Absorbers made of EPDM rubber mat are not recommended. They break down over time when subjected to pool sanitizing chemicals like chlorine, bromine, or copper. In addition, EPDM rubber mats cannot be removed and replaced after reroofing, as the other collectors can.

The best absorber materials are made from UV-stabilized, semirigid, plastic copolymer or polypropylene. These pool collectors will typically last from 12 to 20 years. They are available in standard sizes from 4 by 8 to 4 by 12 feet. Narrower collectors 2 and 3 feet wide are used to fit around plumbing stacks and skylights. Aquatherm in New Jersey makes custom sizes up to 4 by 20 feet.

Since plastic does not transfer heat as well as copper, plastic copolymer collectors have more riser tubes than copper absorber plates. A 4 foot wide copolymer collector will have 100 to 150 risers, whereas a copper absorber will have about 10 risers per 4 foot width. In my experience, risers with a round cross-section are more durable than risers with an oval or a rectangular cross-section.

These lower cost, unglazed collectors hold an advantage over glazed, flat plate collectors when used for low temperature pool heating in mild climates. Pool temperatures are usually under 85°F (29°C) and operate during seasons when the air temperature is over 60°F (15.5°C). During months when air temperature is equal to or greater than the desired pool temperature, there is no thermal efficiency advantage to a collector with an insulated box or glazed cover plate. In fact, the opposite is true.

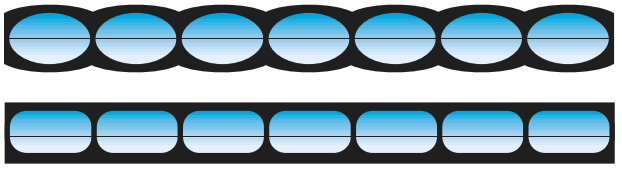
3 gallons of oil, refined & burned, provides 400,000 BTUs ...once.

3 gallons of oil, made into a 4 by 12 foot solar collector, can provide over 10 million BTUs per year...year after year.

Cross-Sections of Various Copolymer Pool Collector Designs

Tube & Web: Author's Preference

Flat Plate: Two variations



Loose Tube

Welded Tube

A glazed cover eliminates approximately 15 percent of the thermal energy reaching the absorber plate. When the air temperature is higher than the pool temperature, the glass-covered, insulated box also minimizes heat gain from ambient air and wind. Sealed Air makes a polymer collector in their FW-series that features a fiberglass glazing cover (called a wind screen) for areas with cold prevailing winds.

Glazed collectors normally used for domestic water heating systems, are much more expensive, and more appropriate for higher temperature end-uses of 120 to 160°F (49–71°C). For pool heating, they are typically used in higher mountain regions, where cold winds prevail, or for indoor winter pool use. For example, in California, glazed collectors will greatly outperform unglazed collectors on the cold and windy Pacific coast. Glazed collectors, most often used for indoor pools, require more collector area than for outdoor pools. But in cold climates, their operating efficiencies are much higher in winter.

To understand the economic sense of using unglazed collectors, consider the Aquatherm Industries 4 by 12 foot plastic copolymer panel, which is rated by the Florida Solar Energy Center (FSEC) to produce 47,200 BTUs per day at 95°F (35°C) inlet temperature. It costs less than US$250. A typical 4 by 10 foot flat plate collector with a glass cover and copper absorber with 1 inch headers would cost over US$780 and is rated at 44,900 BTU per day at the same test inlet temperature. For low temperature uses in mild climates, you get more bang for your buck with an unglazed collector.

The less expensive unglazed collectors will match or outperform an equal area of glazed collectors when air temperatures are less than 20°F (11°C) below the desired pool temperature, and the wind speed is less than 5 mph (2.2 m/s). For example, if you want to keep a pool at 75 to 80°F (24–27°C), unglazed collectors will outperform glazed collectors at or above 55 to 60°F (13–16°C) outdoor ambient air temperature during the day. The unglazed collectors would be capable of producing water temperatures of 75 to 85°F (24–29°C) in this example.

You must be extremely careful with copper collector absorbers, glazed or unglazed. Using excessive chlorine with copper collectors will stain the pool blue-green or black.

Finally, when shopping for your collectors, check the warranty details. Some collectors have a warranty against freeze damage. Manufacturers may also offer a ten-year full replacement warranty with a 50 percent lifetime warranty after the tenth year.

Heating Aboveground Pools

If you think that solar pool heating is only for expensive, inground pools, think again. Smaller solar pool heating systems have become very popular in the northern half of the U.S. over the past five years. Until these newer, low-cost systems became available from SmartPool and other manufacturers, aboveground pool owners had little choice in finding a way to heat their pools. A fossil fuel system can cost almost as much as the pool itself—before the monthly fuel bills start. These smaller (80–160 $ft.^2$; 7.4–14.9 m^2) solar pool heating systems carry a retail price of less than US$400 and are well suited for a shorter season (Memorial Day to Labor Day), which is when these types of pools are in use.

Solar heating is perfect for aboveground pools. Notice the special serpentine collector flow pattern with feed and returns on the same end. The time clock is the only control.

Typically, 4 by 20 or 2 by 20 foot serpentine flow collectors are hose-clamped together to heat the pool. These systems are designed to increase the pool temperature up to 10°F (5.6°C) during the short summer season in the northern U.S. Actually, it is easier to heat an aboveground pool using solar energy for those summer months than an inground pool. The nighttime temperatures stay fairly warm, and aboveground pools tend to heat up more easily. This is because the air is warmer than the ground, and the pool can absorb heat through the sides as well as through the solar pool heat collector.

The cost is lower too, because a manual diverter valve is used rather than a more sophisticated automatic control generally used on larger systems designed for inground pools. Aboveground solar heating systems are usually self-installed and rolled out on the ground next to the pool or put on a homemade rack next to or near the pool, rather than mounted on a roof. All these factors combine to make these systems affordable and very simple to install by the pool owners themselves.

Cut Your Losses

More than 90 percent of all heat lost from a pool is from a combination of surface evaporation, convection, and radiation. Evaporative losses are usually the greatest, at 70 to 85 percent of total losses. Normally, if wind speeds are less than 4 mph (1.8 m/s), only 10 to 15 percent of the heat loss is by wind or convection. Use screens, shrubbery, or a fence around the pool to help cut wind losses. Radiation losses will be on the order of 5 to 15 percent.

With evaporation responsible for the lion's share of energy loss from a swimming pool, a pool cover is a good investment if you want to extend your swimming season. If you use a pool cover to stop overnight heat losses, a solar pool heating system can maintain a pool approximately 20°F (11°C) over the average air temperature on sunny days. For example, if the average outdoor air temperature is 65°F (18°C), your pool will be about 85°F (29°C) if you use a pool cover to retain heat.

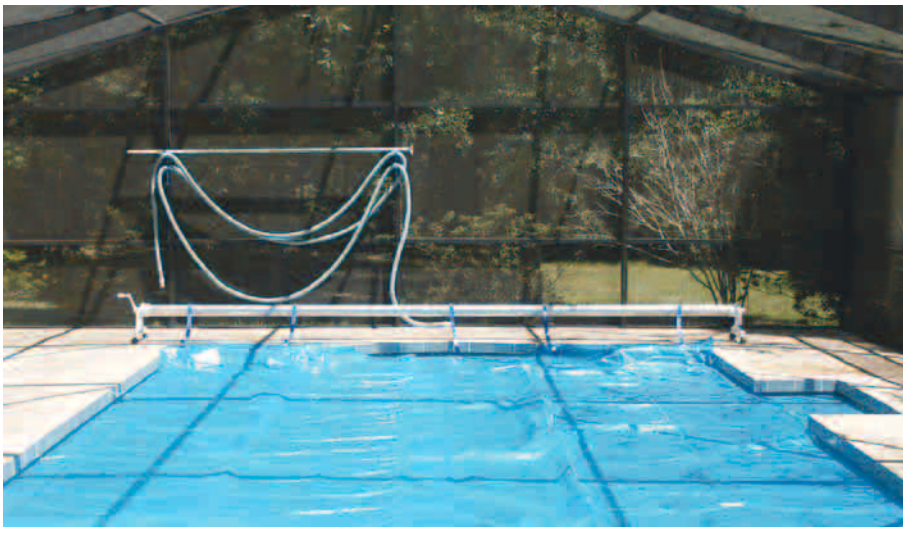
Another strategy to extend your season is to position the pool so that it is in full midday sun during months of use. Also, if you have a screen room over your pool, try to get the widest weave possible. Screen enclosures typically prevent pool temperature gains by from 5 to 10°F (2.8–5.5°C) and even more if the screen accumulates leaves.

Pool Covers

Pool covers (blankets) make pool heating efficient and effective. Pool blankets are bubble packs that float on the pool's surface when the pool is not in use. A clear pool blanket used with a solar pool system can help you

retain an extra 5°F (2.8°C) when used overnight, and an extra 10°F (5.5°C) when used 22 hours a day. Use a pool cover to extend the swim season in early spring and late fall, and for winter use.

Once nighttime temperatures drop below 60°F (16°C), a pool cover will be necessary for your system to heat the pool to over 80°F (27°C). Pool covers are most important in areas that have average wind speeds over 7 mph (3 m/s) and air temperatures colder than the desired pool temperature. This is true even in the tropics. Always use a pool cover in dry western climates with cold clear nights as well. However, an opaque cover provides little benefit to an unheated pool.



A simple, retractable pool cover can maintain water temperatures 10°F higher than an open pool.

Using a quality reel system, one person can easily roll out a pool cover, even on a 20 by 50 foot (6 x 15 m) pool. Rocky's Reel Systems makes a good residential reel. They have an adapter for use with 4 inch aluminum pipe, 1/8 inch (3 mm) thick, which is usually ordered 24 feet (7.3 m) long—to be cut 2 feet (0.6 m) wider than the pool. These tubes or pipes are available from aluminum supply distributors. This is the best reel for larger pools.

A liquid, time-released pool cover is available at www.sunsolar.com. It only works with screened-in pools that are shielded from the wind. Using only a thimbleful each day, the liquid is a food additive and nontoxic. It floats on the surface of the water and prevents evaporative losses of your heated pool water.

The practical limit to which you can raise an outdoor pool's temperature (or an indoor pool in an unheated building) with a pool blanket and solar heating system is about 18 to 25°F (10–14°C) above the temperature of an unheated pool. Without the pool blanket, the heating benefit is limited to 13 to 16°F (7–9°C) above the unheated pool temperature.

Heating a pool without a cover is frequently compared to heating a home with the doors and windows open. It takes one BTU to increase the heat of a pound of water by 1°F. For each pound of 80°F (27°C) water you lose to evaporation, considerable energy is required to replace that temperature loss. Pool covers range in cost from US$0.30 to $0.50 per square foot and last from 2 to 5 years—a bargain compared to adding additional collectors or using backup heating.

Any Other Way to Heat a Pool?

Solar energy isn't the only way to heat a pool, but it's the most economical. A solar pool heating system with unglazed collectors will cost around US$8.50 to US$12 per square foot of collector, depending on the size and system design.

A solar pool heating system with eleven, 4 by 12 panels (528 $ft.^2$; 49 m^2) will cost about US$4,000 to US$5,000 installed. Rated at 528,000 BTUs per day, it would produce around 95 million BTUs during an average 6 month pool season. At the U.S. national average, natural gas costs of US$0.76 per therm, and burned at 80 percent efficiency, it will save more than US$900 each year.

Considering the fact that a gas heater would cost US$1,600 to US$2,000 installed, a solar pool heating system will pay for itself in two seasons. The great news is that people on a limited budget can start with six, 4 by 12 foot collectors rated at 288,000 BTU per day for about US$2,800 to US$3,200, and add more as they can afford them. The economics of solar pool heating systems are even more favorable when compared to propane at US$1.40 a gallon. Heating with propane will exceed the cost of a solar pool heating system in less than one year.

The costs in the table on the next page are for maintaining a 16 by 32 foot (4.9 x 9.8 m) swimming pool at 78, 82, and 86°F (26, 28, and 30°C). Assumed fuel costs are US$0.76 per therm for natural gas and US$1.40 per gallon for propane. The costs for traditional means of pool heating in the table appear enormous,

Annual Pool Heating Costs per Water Temperature & Fuel Type[1]

	78° F		82° F		86° F	
City	*Propane*	*Nat. Gas*	*Propane*	*Nat. Gas*	*Propane*	*Nat. Gas*
Atlanta, GA	$8,608	$4,252	$11,331	$5,977	$15,054	$7,437
Boston, MA[2]	3,223	1,592	4,866	2,403	6,686	3,303
Chicago, IL[2]	3,191	1,577	4,832	2,387	6,649	3,285
Denver, CO[2]	3,412	1,685	5,063	2,501	6,892	3,404
Honolulu, HI	541	267	2,331	1,529	5,768	2,850
Houston, TX	5,733	2,832	7,979	3,941	10,970	5,148
Jacksonville, FL	5,571	2,752	7,902	3,903	11,399	5,601
Kansas City, MO[3]	4,278	2,113	6,090	3,008	8,532	4,215
Little Rock, AR[3]	2,676	1,931	4,083	2,017	6,206	3,065
New York, NY[3]	1,796	2,448	7,116	3,515	9,589	4,736
Orlando, FL	3,610	1,783	5,707	2,819	8,602	4,348
Phoenix, AZ	5,476	2,705	7,698	3,882	10,427	5,150
Reno, NV	6,027	2,977	8,296	4,098	10,010	5,340
Sacramento, CA	8,853	4,373	12,100	5,977	15,854	7,832
San Diego, CA	4,067	2,009	10,525	5,119	14,301	7,605
San Francisco, CA	10,393	5,134	13,802	6,819	17,583	8,686
St. Louis, MO[3]	2,596	5,256	7,510	3,170	7,910	3,907
Tacoma, WA[3]	7,066	3,461	9,265	4,576	11,766	5,012

1. Costs are derived from a computer simulation program, Swimming Pool and Spa Operational Costs Calculator, developed by Aquatherm Industries. A number of variables are entered into the calculator, and costs shown do not necessarily represent accurate figures for calculating payback for solar pool heating. Actual costs for specific locations could be as low as 40% of the figures shown with the addition of a pool cover, fuel price variations, and microclimate specifics.

2. Six months, not annual

3. Eight months, not annual

and you might think that your pool heating system will have a rather quick payback. Typically, payback occurs in three to five years (versus a gas heater), but could be as long as seven years, depending on your use patterns and local conditions. The costs in the table do not reflect using a cover over the pool surface to prevent heat losses at night. All costs in the table can be cut by at least 35 percent when using a cover for 12 hours, and 53 percent when used for 24 hours a day.

In addition, the economics of solar pool heating are often confusing to people who think in terms of collector ratings. The FSEC ratings are relative only to boosting and maintaining the temperature rise in a pool under ideal conditions. The FSEC low temperature pool rating is based on testing with a 95°F (35°C) inlet temperature to the collectors, 81°F (27°C) air temperature, and wind speeds of less than 3 mph (1.3 m/s). In most situations, the collectors will far exceed the FSEC low ratings since pool temperatures are not 95°F. Actual performance of a system is dependent on a number of variables that must be judged subjectively and for each individual microclimate.

To get another view, a computer modeling program that assesses the economics of solar pool heating and other efficiency measures for your pool is available from the U.S. Department of Energy. The free, PC-based software, Energy Smart Pools, can be downloaded from the Energy Efficiency and Renewable Energy Clearinghouse (EREC). However, when it comes to actually sizing your system, most collector manufacturers have more accurate programs to help you out.

Just Add Water

A solar pool heating system requires little or no maintenance since there are no burners and no moving parts. You should check the clamps used to connect the solar collectors annually, particularly in hot climates where they may become loose. If you are operating your system year-round, you will need to take precautions during freezing weather conditions.

A gas heater or heat pump requires more maintenance, and generally lasts only one-third the lifespan of a solar pool heating system. Solar pool heating system warranties are typically more inclusive and much longer (12 years plus) than warranties for gas heaters and heat pump systems (usually 5 years).

In case I have understated the simplicity and good sense of solar pool heating systems, let's recap the high points of this article. Your pool is your storage tank, so you won't need to buy a tank. Your pool already has a pump, so you won't need to buy a pump. The pump is already circulating water through the filter at least 6 hours a day, so you won't need to run it any more than that. Solar pool heaters are inexpensive and operate under conditions of highest efficiency, since several components fulfill dual roles. What else do you need? A collector, a controller, and some pipe—then just add water.

Access

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www.ecs-solar.com • Article adapted from Tom's *Solar Hot Water Systems: Lessons Learned, 1977 to Today.*

Florida Solar Energy Center (FSEC), 1679 Clearlake Rd., Cocoa, FL 32922 • 321-638-1000 or for publications 321-638-1015 • Fax: 321-638-1010 info@fsec.ucf.edu • www.FSEC.UCF.edu • Pool collector ratings

Goldline Controls, Inc., 42 Ladd St., East Greenwich, RI 02818 • 800-343-0826 or 401-884-6990 Fax: 800-343-0827 or 401-885-1500 customerservice@goldlinecontrols.com www.goldlinecontrols.com • Controllers and diverter valves

Pentair Pool Products, 1620 Hawkins Ave., Sanford, NC 27330 • 800-831-7133 or 919-774-4151 Fax: 919-776-4571 • pentair@speedymail.com www.pentairpool.com • Controllers and diverters

Aquatherm Industries, Charlie Grignon, 1940 Rutgers University Blvd., Lakewood, NJ 08701 • 800-535-6307 or 732-905-9002 • Fax: 732-905-9899 aquatherm@aol.com • www.warmwater.com Copolymer collectors

FAFCO, Inc., 435 Otterson Dr., Chico, CA 95928 530-332-2100 • Fax: 530-332-2109 • sales@fafco.com www.fafco.com • Collectors

Sunwest Solar Inc., Sealed Air Distributor, 645 N. Eckhoff St. #M, Orange, CA 92868 • 800-786-8110 or 714-712-6233 • Fax: 714-712-6230 Dbosio123@aol.com • www.sunwestsolar.com Collectors

Heliocol, USA, 927 Fern St., Ste. 1500, Altamonte Springs, FL 32701 • 800-797-6527 or 407-831-1941 Fax: 407-831-1208 • heliocol@umasolar.com www.heliocol.com • Collectors

SmartPool, Inc., 575 Prospect St., Lakewood, NJ 08701 888-560-7665• info@smartpool.com www.smartpool.com • Aboveground solar pool heaters

Rocky's Reel Systems Inc., 1305 Welch St. #113, North Vancouver, B.C., Canada, V7P 1B3 • 800-663-8705 or 604-985-0525 • Fax: 800-811-9966 info@rockysrollers.com • www.rockysrollers.com Reels and pool covers

Cantar/Polyair, 1100 Performance Pl., Youngstown, OH 44502 • 800-448-2343 or 330-744-8812 Fax: 330-744-1228 • info@cantar.com www.cantar.com • Reels and pool covers

Leslie's Swimming Pool Supplies • 800-275-5882 customerservice@lesl.com www.lesliespoolsupplies.com • Pool blankets

Sunsolar Energy Technologies, 3262 F-X Tessier, Vaudreuil-Dorion, Quebec, Canada J7V 5V5 888-357-6527 • Fax: 450-424-5757 sales@sunsolar.com • www.sunsolar.com Liquid pool covers

Letro Products, 1497 George Dr., Redding, CA 96003 800-223-1695 or 530-247-8181 • Fax: 530-247-8191 customercare@letro.com • www.letro.com • In-line pool thermometers

Energy Efficiency and Renewable Energy Clearinghouse (EREC), PO Box 3048, Merrifield, VA 22116 • 800-363-3732 • doe.erec@nciinc.com www.eren.doe.gov/rspec/software.html • Energy Smart Pools software