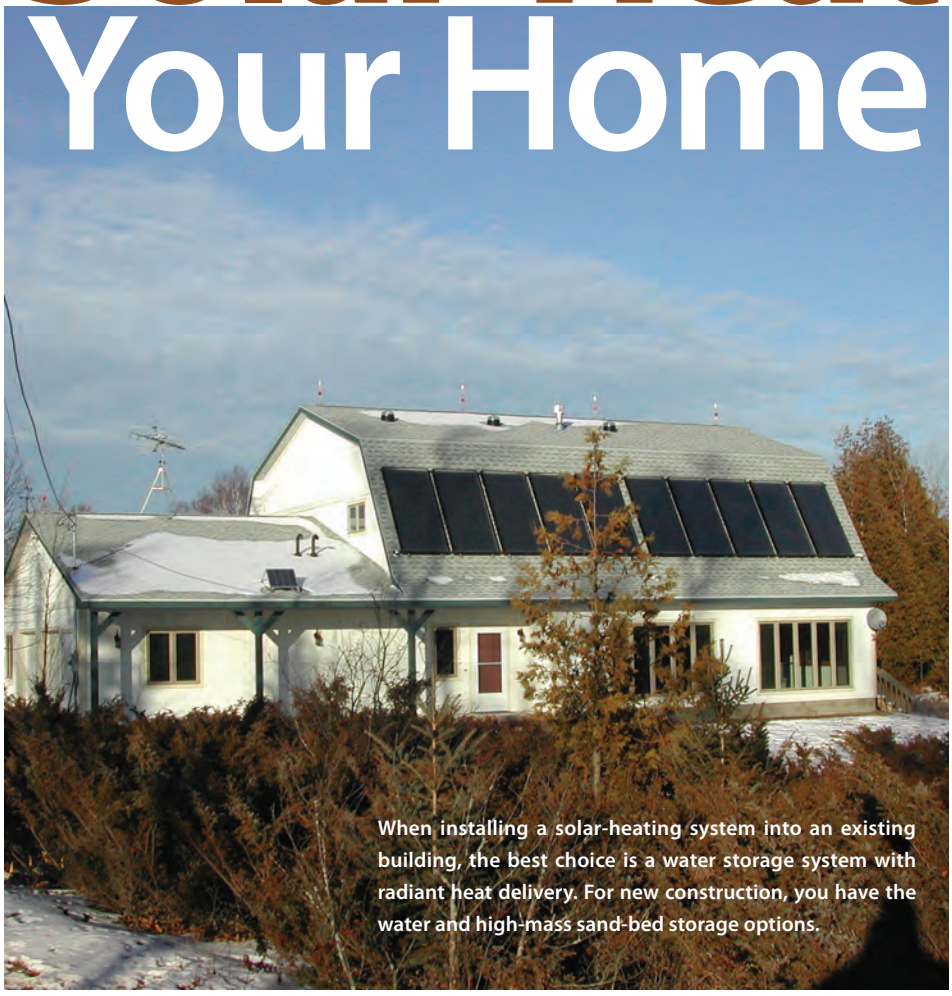
Solar-Heat Your Home



When installing a solar-heating system into an existing building, the best choice is a water storage system with radiant heat delivery. For new construction, you have the water and high-mass sand-bed storage options.

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By **BOB RAMLOW**

For its comfort and economy, radiant heating is growing in popularity. Pairing a radiant heat-delivery system with solar energy as the heat source is an excellent choice for several reasons. Above all, these systems can operate efficiently and effectively at the relatively low temperatures common with solar energy systems. They're relatively easy to retrofit into an existing building and can be easily incorporated into new construction. Some systems can be accurately controlled, just like conventional heating systems. Radiant systems are virtually maintenance free, and because they use no fans, they don't circulate dust and allergens around the home. They're often the least expensive heating systems to operate.

Radiant system components are readily found at plumbing supply stores, and system cost will depend on the difficulty of the installation. Integrating solar heat into a radiant system is relatively easy for most good plumbers. Before we get started designing a solar radiant heating system, it is prudent to know how these systems work and to understand our options.

Radiant heating systems are almost always the best way to deliver solar heat into a building.

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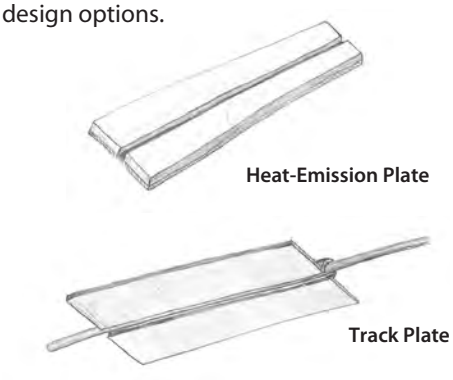
How Radiant Differs From Other Heating

Radiant heating generally refers to heat-delivery systems that rely on electromagnetic waves to warm surfaces. The sun's energy that hits the earth is electromagnetic energy, including visible waves we know as sunlight. Sunlight is radiant energy that transforms into heat energy when it contacts a physical surface, like the absorber plate in a solar thermal collector. The heat is conducted through the metal of the absorber to a heat-transfer fluid, which then is pumped to where it is needed or will be stored for later use.

Radiant heating systems rely on electromagnetic waves that we cannot see, but we can feel them as warmth. Imagine a flat panel that is like the absorber plate in a solar thermal collector. If we circulate a hot fluid through our flat panel and if the panel is warmer than the surrounding air, then the panel will emit radiation in the form of electromagnetic waves into the surrounding space. When this radiation hits a solid object, the object will get warm. When the object gets warm it will, in turn, warm the air that surrounds it. In other words, radiant heating systems heat things rather than directly heating air. By contrast, traditional forced-air heating systems and traditional hydronic heating systems heat air, and the warm air heats things it comes into contact with through convection and conduction.

Solar Radiant Floor Heating

Aluminum heat-emission plates fit between floor joists to transfer to flooring heat delivered via a solar-heated liquid. Here are two design options.



The point of the above descriptions is to clearly show how fundamentally different radiant heating systems are from conventional heating systems. Conventional systems have to fill the conditioned space with hot air to achieve the desired temperature, while radiant heating systems heat the objects in the space.

Any heating system comprises two main components: the heat source and the heat-delivery system. Most radiant heating systems rely on a boiler to heat a liquid that is then piped to some type of heat-transfer device, like baseboard radiators or radiant floor, wall or ceiling panels. Resistance electric heating could also be used where heating cables are embedded in floors, walls or ceilings, in which case the heat source and delivery system are the same heating cables. Baseboard radiators and most old-fashioned radiators actually work on the principle of convection, whereby the radiators heat air that is then circulated throughout the room by convection.

The operating temperature of the heating system and the heat load of the room being heated determine the size of the radiator needed. The warmer the operating temperature, the smaller the radiator need be to deliver a determined amount of heat. Conversely, the lower the temperature of the heating system, the larger the radiator needs to be to deliver an equal amount

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Radiant wall panels are an excellent way to distribute solar heat in a building. Running the piping is a little more difficult than for floor systems, but note that these panels can be mounted either on interior or exterior walls.

RADIANTEC

Radiant floor systems are relatively easy to install in buildings with unfinished basements offering easy access to the underside of the main-level floor.

RADIANTEC

Aluminum heat-emission plates, like the homemade plates shown above, are sized to fit between floor joists. One or two grooves bent into the flat plate accommodate pex tubing.

of heat. Modern radiant floor heating systems can operate at much lower temperatures than traditional hydronic heating systems — typically around 100°F (38°C) — because the radiators are very large, in this case the whole floor of the building. This is the critical point when relating to solar heating because solar heating systems typically operate at relatively low temperatures. It is common to see solar storage tanks operate within the 100°F to 150°F range (38°C to 66°C), while traditional baseboard heating systems typically operate at 180°F (82°C).

When it comes to finding the radiant heating system you'd like to install, it soon becomes obvious that radiant floor-heating systems are the most common type in the United States. Radiant floor heating has been refined in Europe for 50 years, but it's only caught on here in the last 15 years. I have mentioned radiant wall- and radiant ceiling-heating systems as viable options, and while these types of systems have been the norm in Europe for at least 25 years, they remain rare here in the States. The radiant options we have to choose from are radiant floors, walls and ceilings.

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Storing Heat for Later Use

This article focuses on solar heating systems with heat storage, whereby solar heat collected during sunny hours is stored for use later. The two popular options for heat-storage media used in solar space-heating systems are water (or a water/antifreeze solution) and some type of solid, like sand. Note that whether you use a water tank or sand bed for storage, backup heating is required in virtually all climates.

Since the beginning of the modern solar era in the mid-1970s, the most common type of heat storage has been water. My article, "Warm, Radiant Comfort in the Sand" (*SOLAR TODAY,* November/December 2007), compares water and sand for heat storage. Water storage offers precise temperature control and high efficiency, but it is limited to one or two days of heat storage. Sand-bed storage offers long-term storage capacity for installations where winters are long and cold.

For situations where you want to install a solar heating system into an existing building, the best choice is a water storage system with radiant heat delivery. For new construction, you have the water and high-mass sand-bed storage options.

The first step when considering your storage options is to size the solar energy system to meet your heating needs. Sizing space-heating systems can be a challenge, but two resources can walk you through it. My *SOLAR TODAY* article mentioned previously details a simple formula that has been used very successfully; access it at solartoday.org/ramlow. You can also find several sizing methods in my book, *Solar Water Heating, A Comprehensive Guide to Solar Water & Space Heating Systems.*

Space heating in cold climates requires a substantial number of solar collectors, and finding enough room for them may be difficult. For most existing buildings, the final size of the collector array will be limited to available space for them. Next, if you'll use water for heat storage, you will need to identify a place for the water-storage tank. Lastly you will need to identify the radiant heat-delivery system that will work best for your building.

Designing Heat Delivery for Retrofit

Two popular retrofit systems are the least invasive to install: radiant floor or radiant wall panels, with water for heat storage.

Radiant floor systems are relatively easy to install in buildings with unfinished basements offering easy access to the underside of the main-level floor. If you are lucky enough to have this situation in your building, your installation can be fairly easy. Aluminum heat-emission plates, usually about 2 feet (60 cm) long, are sized to fit between floor joists. One or two grooves bent into the flat plate accommodate pex tubing. You run the pex tubing between the floor joists, snap the pex into the plate and staple the plate to the underside of the floor. Insulation is then installed under the plates to ensure all the heat dissipated by the plates radiates up.

Another radiant floor system uses what I call a track plate — a flat aluminum plate fastened to strips of plywood. These track plates come in different sizes, but imagine a 12- by 24-inch

CLICK: Access the author's past *SOLAR TODAY* articles detailing how to install a sand-bed solar radiant system and a case study of his own solar-heated net-zero-energy home: solartoday.org/ramlow

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In high-mass solar heating systems, a sand bed typically 2 feet (61 cm) deep covers the building's entire footprint. A gridwork of pex tubing is installed in the sand bed, with solar-heated fluid pumped through. A concrete slab is poured over the compacted sand, and heat radiates through the floor and into the building.

(30- by 61-cm) aluminum plate with two strips of three-eighths-inch-thick plywood attached to the top side, covering the whole aluminum plate except for a three-eighths-inch-wide groove running the length of the piece. The track plates are attached to the top of the floor and aligned so the grooves create a long channel. The room's entire floor is covered with the track plates, creating a parallel grid of grooves. You'll snap pex tubing the same depth as the plywood into the grooves, creating a flat surface that can be covered with tile or hardwood. In a retrofit, installing track plates will require all doors and trim to be cut to accommodate the new floor height.

Radiant wall panels are another excellent way to distribute solar heat in a building, with many fashionable, affordable products on the market. These panels come in countless sizes. When sizing the panel for a room, calculate the heating needs of the room on the coldest day of the year and match the British thermal unit (Btu) output of a panel or panels to meet the calculated load. Be aware that the Btu output of a panel is directly related to the temperature of the heat-transfer fluid passing through it. For solar heating systems, figure that the average fluid temperature coming out of a solar storage tank during the winter in northern climates will be around 120°F (49°C). For places outside the northern states, a good winter benchmark is 140°F (60°C).

Installing panel radiators in a retrofit situation is remarkably easy. Most hang on brackets attached to the studs in the wall. Running the piping is a little more difficult, but note that these panels can be mounted either on interior or exterior walls. Much of the hidden piping can be pex, which is easy to run.

Get More Info

Solar Water Heating, A Comprehensive Guide to Solar Water & Space Heating Systems, by Bob Ramlow & Benjamin Nusz, New Society Publishers: arthaonline.com

Solar Hot Water Systems, Lessons Learned 1977 to Today, by Tom Lane, ECS Solar: ecs-solar.com

Radiant Panel Association: radiantpanelassociation.org

Designing for New Construction

In new construction or major renovations, we have all the retrofit options detailed above, along with concrete-based floors, walls and ceilings. We also have the option of using a sand bed for heat storage with the concrete floor.

When it comes to water storage systems, the most familiar radiant floor heating has pex tubing embedded in concrete floors. The tubing can be embedded in a traditional on-grade slab or in a lightweight concrete or gypcrete slab poured over wooden subfloors. Concrete-based systems are slower to heat up or cool down compared to heat-emission-plate systems, but they retain heat longer, making temperatures more stable in the buildings they serve. Note that floor coverings over radiant floor systems significantly impede the systems' heating ability. Any sort of covering other than ceramic tile will act like insulation, inhibiting the radiant waves.

Radiant walls and radiant ceilings are easy to incorporate into new construction or in major remodeling projects where walls or ceilings are opened up. To create a radiant wall or ceiling, track plates are installed directly into the studs of an insulated wall or ceiling, and drywall is applied over the track-plate system. Normally the track plates are located in the middle section of the wall, below where pictures hang. You do not want to puncture the pex tubing that will be in the wall when hanging pictures. Of course this is not an issue if the radiant track plates are in the ceiling.

As a side note, we have two radiant walls in our new home, which was featured in *SOLAR TODAY's* March/April 2008 issue (see "Warmed by the Sun in Wisconsin" at solartoday.org/ramlow). These radiant walls are simply amazing. They're completely undetectable and do a fantastic job of heating the rooms in which they're installed.

I have saved the sand-bed system, my favorite solar heating system, for last. High-mass solar heating systems are great for new construction and some retrofits. In these systems, a sand bed typically 2 feet (61 cm) deep covers the building's entire footprint. A gridwork of pex tubing is installed in the sand bed, with solar-heated fluid pumped through. A concrete slab is poured over the compacted sand, and heat radiates through the floor and into the building.

I've described sand-bed systems in both my previous *SOLAR TODAY* articles, as well as in my book. Since 18 months ago, when I last reported in these pages, a winter has passed and we continue to be impressed with the performance of our sytem. We're so impressed, in fact, that we're now retrofitting our 100-year-old farmhouse/bed and breakfast with a sand bed. ST