In-wall radiant heating in a house under construction near Denver. | Photo courtesy of Warren Gretz, NREL.

Radiant heating systems supply heat directly to the floor or to panels in the wall or ceiling of a house. The systems depend largely on radiant heat transfer -- the delivery of heat directly from the hot surface to the

people and objects in the room via infrared radiation. Radiant heating is the effect you feel when you can feel the warmth of a hot stovetop element from across the room. When radiant heating is located in the floor, it is often called radiant floor heating or simply floor heating.

Radiant heating has a number of advantages. It is more efficient than baseboard heating and usually more efficient than forced-air heating because it eliminates duct losses. People with allergies often prefer radiant heat because it doesn't distribute allergens like forced air systems can. Hydronic (liquid-based) systems use little electricity, a benefit for homes off the power grid or in areas with high electricity prices. Hydronic systems can use a wide variety of energy sources to heat the liquid, including standard gas- or oil-fired boilers, wood-fired boilers, solar water heaters, or a combination of these sources. For more on the different types of energy sources and heat distribution systems for home heating, explore our Energy Saver 101 infographic on home heating.

Despite its name, radiant floor heating depends heavily on convection, the natural circulation of heat within a room as air warmed by the floor rises. Radiant floor heating systems are significantly different from the radiant panels used in walls and ceilings. For this reason, the following sections discuss radiant floor heat and radiant panels separately.

RADIANT FLOOR HEAT

There are three types of radiant floor heat -- radiant air floors (air is the heat-carrying medium), electric radiant floors, and hot water (hydronic) radiant floors. You can further categorize these types by installation. Those that make use of the large thermal mass of a concrete slab floor or lightweight concrete over a wooden subfloor are called "wet installations," and those in which the installer "sandwiches" the radiant floor tubing between two layers of plywood or attaches the tubing under the finished floor or subfloor are called "dry installations."

Types of Radiant Floor Heat

AIR-HEATED RADIANT FLOORS

Air cannot hold large amounts of heat, so radiant air floors are not cost-effective in residential applications, and are seldom installed. Although they can be combined with solar air heating systems, those systems suffer from the obvious drawback of only producing heat in the daytime, when heating loads are generally lower. The inefficiency of trying to heat a home with a conventional furnace by pumping air through the floors at night outweighs the benefits of using solar heat during the day. Although some early solar air heating systems used rocks as a heat-storage medium, this approach is not recommended (see solar air heating systems).

ELECTRIC RADIANT FLOORS

Electric radiant floors typically consist of electric cables built into the floor. Systems that feature mats of electrically conductive plastic mounted on the subfloor below a floor covering such as tile are also available.

Because of the relatively high cost of electricity, electric radiant floors are usually only cost-effective if they include a significant thermal mass such as a thick concrete floor and your electric utility company offers time-of-use rates. Time-of-use rates allow you to "charge" the concrete floor with heat during off-peak hours (approximately 9 p.m. to 6 a.m.). If the floor's thermal mass is large enough, the heat stored in it will keep the house comfortable for eight to ten hours without any further electrical input, particularly when daytime temperatures are significantly warmer than nighttime temperatures. This saves a considerable number of energy dollars compared to heating at peak electric rates during the day.

Electric radiant floors may also make sense for home additions if it would be impractical to extend the heating system into the new space. However, homeowners should examine other options, such as mini-split heat pumps, which operate more efficiently and have the added advantage of providing cooling.

HYDRONIC RADIANT FLOORS

Hydronic (liquid) systems are the most popular and cost-effective radiant heating systems for heating-dominated climates. Hydronic radiant floor systems pump heated water from a boiler through tubing laid in a pattern under the floor. In some systems, controlling the flow of hot water through each tubing loop by using zoning valves or pumps and thermostats regulates room temperatures. The cost of installing a hydronic radiant floor varies by location and depends on the size of the home, the type of installation, the floor covering, remoteness of the site, and the cost of labor.

TYPES OF FLOOR INSTALLATIONS

Whether you use cables or tubing, the methods of installing electric and hydronic radiant systems in floors are similar.

So-called "wet" installations embed the cables or tubing in a solid floor and are the oldest form of modern radiant floor systems. The tubing or cable can be embedded in a thick concrete foundation slab (commonly used in "slab" ranch houses that don't have basements) or in a thin layer of concrete, gypsum, or other material installed on top of a subfloor. If concrete is used and the new floor is not on solid earth, additional floor support may be necessary because of the added weight. You should consult a professional engineer to determine the floor's carrying capacity.

Thick concrete slabs are ideal for storing heat from solar energy systems, which have a fluctuating heat output. The downside of thick slabs is their slow thermal response time, which makes strategies such as night or daytime setbacks difficult if not impossible. Most experts recommend maintaining a constant temperature in homes with these heating systems.

Due to recent innovations in floor technology, so-called "dry" floors, in which the cables or tubing run in an air space beneath the floor, have been gaining in popularity, mainly because a dry floor is faster and less expensive to build. But because dry floors involve heating an air space, the radiant heating system needs to operate at a higher temperature.

Some dry installations involve suspending the tubing or cables under the subfloor between the joists. This method usually requires drilling through the floor joists to install the tubing. Reflective insulation must also be installed under the tubes to direct the heat upward. Tubing or cables may also be installed from above the floor, between two layers of subfloor. In these instances, liquid tubing is often fitted into aluminum diffusers that spread the water's heat across the floor in order to heat the floor more evenly. The tubing and heat diffusers are secured between furring strips (sleepers), which carry the weight of the new subfloor and finished floor surface.

At least one company has improved on this idea by making a plywood subfloor material manufactured with tubing grooves and aluminum heat diffuser plates built into them. The manufacturer claims that this product makes a radiant floor system (for new construction) considerably less expensive to install and faster to react to room temperature changes. Such products also allow for the use of half as much tubing or cabling, because the heat transfer of the floor is greatly improved compared with more traditional dry or wet floors.

FLOOR COVERINGS

Ceramic tile is the most common and effective floor covering for radiant floor heating, because it conducts heat well and adds thermal storage. Common floor coverings like vinyl and linoleum sheet goods, carpeting, or wood can also be used, but any covering that insulates the floor from the room will decrease the efficiency of the system.

If you want carpeting, use a thin carpet with dense padding and install as little carpeting as possible. If some rooms, but not all, will have a floor covering, then those rooms should have a separate tubing loop to make the system heat these spaces more efficiently. This is because the water flowing under the covered floor will need to be hotter to compensate for the floor covering. Wood flooring should be laminated wood flooring instead of solid wood to reduce the possibility of the wood shrinking and cracking from the drying effects of the heat.

RADIANT PANELS

Wall- and ceiling-mounted radiant panels are usually made of aluminum and can be heated with either electricity or with tubing that carries hot water, although the latter creates concerns about leakage in wall- or ceiling-mounted systems. Most commercially available radiant panels for homes are electrically heated.

Like any type of electric heat, radiant panels can be expensive to operate, but they can provide supplemental heating in some rooms or can provide heat to a home addition when extending the conventional heating system is impractical.

Radiant panels have the quickest response time of any heating technology and -- because the panels can be individually controlled for each room—the quick response feature can result in cost and energy savings compared with other systems when rooms are infrequently occupied. When entering a room, the occupant can increase the temperature setting and be comfortable within minutes. As with any heating system, set the thermostat to a minimum temperature that will prevent pipes from freezing.

Radiant heating panels operate on a line-of-sight basis -- you'll be most comfortable if you're close to the panel. Some people find ceiling-mounted systems uncomfortable because the panels heat the top of their heads and shoulders more effectively than the rest of their bodies.

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