

**RESEARCH TOPIC ACCEPTANCE REQUEST**  
**TC 6.7 – Solar Energy Utilization**

**TITLE:** Development of Solar-assisted Radiant Heating and Cooling Systems

**RESEARCH CATEGORY:** Applied Research

**RESEARCH CLASSIFICATION:** Design Tools

**TC/TG PRIORITY:** 1

**ESTIMATED COST:** \$250,000 (ASHRAE contribution to this project is expected to be 50% (\$125,000))

**OTHER INTERESTED TC/TGS:** TC 6.5 – Radiant Space Heating and Cooling

**POSSIBLE CO-FUNDING ORGANIZATIONS:** U.S. Department of Energy – Solar Energy Technologies Program

**HANDBOOK CHAPTERS TO BE AFFECTED BY RESULTS OF THIS PROJECT:** 33 – “Solar Energy Equipment,” HVAC Systems and Equipment

**BACKGROUND / STATE-OF-THE-ART:** The efficiency of a solar heating and/or cooling system increases as the required application temperature approaches the ambient temperature. Hence, processes that do not require very high or low temperatures to heat or cool buildings will be significantly more compatible with solar energy than conventional heating and cooling methods that require temperatures that are at least 15 to 20 C above or below room temperature. As indicated in the ASHRAE HVAC Applications Handbook, radiant heating and cooling can occur at temperatures that are only slightly different (~5 C) from room temperature. Furthermore, normal operating temperatures for radiant heating and cooling systems are closer to ambient temperature than conventional convection-based heating and cooling systems. Therefore, radiant heating and cooling is a potentially favorable application for solar-assisted heating and cooling. However, little work has been done to-date on optimizing the sizing of solar-assisted radiant heating systems and even a smaller amount of work has been done on using solar collectors to provide nighttime heat rejection for radiant cooling systems.

For solar heat collection, unglazed solar collectors are more efficient than glazed collectors due to the effect of no glazing transmission losses. However, unglazed solar collectors are not able to reach as high a temperature as glazed collectors. For nighttime heat rejection, unglazed collectors also outperform typically glass-covered solar collectors, since glass is not transparent to short-wave infrared radiation. Unglazed collectors also have potential for lower cost and better aesthetics compared to conventional glazed collectors.

**ADVANCEMENT TO THE STATE-OF-THE-ART:** Radiant heating and cooling is well understood and is often used in European building design. However, the combination with solar

energy and, in particular, unglazed solar collectors is not well studied and will require new research, simulation modeling, and testing. In addition, the unglazed collector/radiant heating and cooling combination is not suitable for all climates. However, for much of the U.S. Southwest, the benefits that solar radiant heating and cooling systems bring to the HVAC engineer need to be well understood. Sizing methods need to be established for solar-assisted radiant heating systems, while practical experience needs to be documented for radiant cooling systems using solar collectors for nighttime heat rejection. System testing and validated simulation modeling for both types of solar-assisted radiant heating and cooling systems need to be performed.

**JUSTIFICATION / VALUE TO ASHRAE:** As with other technologies that replace non-renewable resources with renewables, the successful introduction of a solar-assisted radiant heating and cooling system will provide many strategic benefits including (1) reduction in pollution and the potential for climate change, (2) conservation of non-renewable resources, (3) reduction in imported energy, and (4) protection from energy price fluctuations and the disruptions they cause. In addition to these benefits, the proposed project will provide very concrete information on the characteristics of solar radiant heating and cooling systems. Since a large majority of engineers are unfamiliar with both radiant heating and cooling systems as well as solar thermal systems, this information on system performance, sizing requirements, and O&M needs will be an important first step at introducing the technology to the ASHRAE community.

**OBJECTIVE:** The overall objective of the proposed project is to create a design guide for the utilization of solar-assisted radiant heating and cooling systems. A design guide that summarizes the design possibilities and challenges will increase the HVAC engineers' understanding of these kinds of systems. However, in order to develop a design guide, testing and simulation of solar-assisted radiant heating and cooling systems needs to be performed. A one-year field test of a solar-assisted system in an applicable climate -- in parallel with energy simulation modeling -- should help determine the necessary information that a design guide requires. In addition, a literature review needs to be performed to identify other possible systems for validating the design and sizing information.

The design guide should also address unique opportunities that arise with solar-assisted systems such as thermal storage in the building combined with passive solar gain through fenestration. Finally, a design guide should identify the most promising applications of a solar-assisted radiant heating and cooling system -- a system that reduces energy consumption as well as often improves the indoor air quality of buildings.