

A thermal image of a laboratory interior. The image shows a room with a large window on the left side. The floor is covered with a grid of radiant heating and cooling panels. The temperature distribution is visible, with warmer areas (yellow and orange) and cooler areas (purple and blue). The text 'FLEXLAB®' is overlaid at the top center.

FLEXLAB®

VERIFYING THE BENEFITS OF RADIANT HEATING AND COOLING

PG&E gains valuable insights on radiant system performance

THE CHALLENGE

Testing new heating and cooling options

PG&E operates a wide range of building energy efficiency programs designed to meet its energy and demand goals. The California utility is interested in shifting its programs from component-based solutions to more innovative integrated system solutions, including radiant heating and cooling. But how well do these systems work in the real world, and what's the most effective way to implement them?

PG&E was interested to characterize radiant heating and cooling system behavior for designers and provide information that can reduce both the cost and the perceived risk. The utility's goal is to improve energy performance and comfort by encouraging the appropriate adoption of radiant systems in both new construction and retrofits of commercial buildings in California. It also needs to assess the benefits of integrated control of HVAC, active facades and daylight harvesting.

THE SOLUTION

PG&E turned to U.S Department of Energy's FLEXLAB® facility at Lawrence Berkeley National Laboratory to test two types of radiant heating and cooling systems: floor-slabs and ceiling panels. FLEXLAB enables repeatable experiments in 600 square foot test chambers that mirror a perimeter zone in a commercial building. Researchers evaluated the systems' ability to save energy while keeping the indoor environment comfortable.



THE BOTTOM LINE

Useful insights for the appropriate use of radiant heating and cooling systems in California

California has set aggressive goals for efficiency improvements in commercial buildings, both for retrofit and for new construction. Utility companies have a substantial role to play in enabling these efficiency improvements, but they need credible data on how technologies behave to support their deployment through incentive programs.

Data from FLEXLAB's® test chambers provided PG&E with useful design guidance for radiant system sizing and zoning, and for the associated level of controls complexity. The study also revealed where more work needs to be done—for example, in further developing control methods for radiant slab systems. FLEXLAB's unique capabilities made it possible for PG&E to test these energy efficient technologies of relevance to California and for locations with similar climates, against a range of variables in real-world conditions.

THE EXPERIMENT

- Systems were evaluated in FLEXLAB in March and April, 2016.
- Two different radiant heating and cooling systems were studied: a radiant ceiling panel system and a radiant cooling slab system. A reference cell had cooling and heating supplied by a dedicated air-handling unit served by hot and chilled water.
- To simulate realistic office conditions, six work spaces consisting of thermal manikins, computers, desks and partitions were set up, together with ceiling fans and artificial light. Three ceiling fans were installed to investigate their impact on temperature and air flow.
- Sixty-one temperature sensors were used to measure the surface temperatures of the walls, windows, floor and ceiling, with every surface having at least six temperature sensors.
- Different control configurations were tested at different times with different HVAC configurations, to separate the effects of the various controls. The relevant market for these systems is new or existing commercial office buildings or buildings with similar use patterns.
- Computer simulation was used to analyze the expected benefits of radiant panel cooling and heating in medium-size office buildings in four California locations that represent different climate zones: San Jose, Los Angeles International Airport, Los Angeles Civic Center and Stockton.

THE RESULTS

- Simulations in four climate zones show radiant ceiling panel systems can deliver HVAC energy savings ranging from 14% to 24% compared to conventional, Title 24-compliant, variable-air-volume systems.
- Both radiant panel and radiant slab cooling systems can provide thermal comfort at the modest zone cooling loads typical of well-designed office buildings, enabling low-energy designs based on water-side free cooling in suitable areas, such as California coastal climates.
- Radiant slab systems can provide significant peak load shifting and smoothing, although they are primarily suited to new construction with limited retrofit potential.
- Radiant panel systems, which can be retrofitted into conventional T-bar ceiling systems, can provide good thermal comfort conditions with good dynamic response to varying internal and solar gains.
- Simulation results indicated negligible benefit from the use of integrated control of active facades, HVAC and daylight harvesting systems in medium-size office buildings with radiant panel systems.