On the energy and environmental assessment of PECS in office buildings. Findings from Italian Living Labs experience

Michele Zinzi[1]*, Martina Botticelli[1], Agnese Chiucchiù[2], Anna Laura Pisello[2,3]

1 ENEA – Energy Technologies Department
Via Anguillarese 301, 00123 Tom
00123 Rome, Italy

2 EAPLAB at CIRIAF, Interuniversity Research Center, University of Perugia
Via G. Duranti, 67,
06125 Perugia, Italy

3 Department of Engineering, University of Perugia
Via G. Duranti, 93
06125 Perugia, Italy

ABSTRACT

Personalized environmental comfort systems (PECS) represent a promising solution to simultaneously enhance occupants' comfort conditions and reduce the building energy consumption. Despite the concept dates to several decades, interest in PECS has increased significantly in recent years, particularly following the activities carried out within the Annex 87 - Energy and Indoor Environmental Quality Performance of PECS framework, an international project developed within the IEA Energy in Buildings and Communities Programme.
PECS can address multiple indoor environmental domains; however, this study focuses on convective PECS for thermal comfort enhancement and energy-saving strategies during heating and cooling seasons. The experimentation was conducted in two Living Labs in central Italy, namely in Perugia (LL1) and Rome (LL2) during January and July 2025, through the energy and environmental monitoring. The main objective was to assess whether, and to what extent, PECS may reduce or replace conventional heating and cooling systems. Three distinct operational scenarios were identified: (i) cooling/heating systems operating under standard conditions, (ii) PECS operating as replacement for conventional systems, (iii) PECS integrated with conventional systems operated under relaxed set-points (28°C instead of 26° and 20°C instead of 22°C in summer and winter, respectively). The winter PECS consisted of a 370W constant power fan heater, with adjustable set-point through a knob by the user; while the summer PECS was an evaporative fan cooler (40W peak power), also operable as a standard fan if no water was used.
Indoor environmental quality and user acceptance were assessed through surveys completed by more than 22 participants, designed in accordance with validate questionnaire to evaluate sensation, satisfaction and preference. Beside the environmental quality, participants also provided qualitative feedback on their experience with the PECS technology. PECS energy consumption was monitored using smart metering plugs connected to the building grid, while the energy use of conventional systems was directly measured in LL2 and estimated in LL1 based on set-point changes and associated calculations.
Results indicate that PECS cannot realistically replace conventional heating and cooling systems, at least in the tested environments. However, PECS proved effective when integrated with conventional room systems operating at relaxed set-points, as confirmed by users' feedback. In this configuration, PECS demonstrated potential energy savings during the cooling season due to their low power demand. Conversely, winter results were mixed, reflecting the low energy demand of both Living Labs and the relatively high-power absorption of fan heaters. Overall, the results highlight the energy-saving potential of PECS, while emphasizing the need for further development of low-energy PECS technologies to maximize their effectiveness.

KEYWORDS

Personalized environmental comfort systems (PECS), Living Lab, energy monitoring, indoor environmental quality, users' acceptance