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

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Introduction

- Personalized environmental control systems (PECS) may enhance comfort conditions and wellbeing as they allow users to tune the local environment to their expectations.
- PECS apply to several domains of the indoor built environment: thermal, air quality, lighting, and acoustics.
- PECS may ensure energy savings by providing the required service in the user’s proximity instead of the entire indoor environment
- Concepts and initial application on PECS date back to almost fifty years; nevertheless, the market penetration is still very limited because of economic, technical and behavioral issues
- IEA EBC - Annex 87 - Energy and Indoor Environmental Quality Performance of Personalised Environmental Control Systems explores the potential of the technology to quantify the benefits regarding health, comfort and energy performance

Aims and objective

- Assess if and how PECS can be applied in offices to reduce the related building energy services, while ensuring comfort conditions for the building occupants
- Targeted domains:
  - Space Heating
  - Space Cooling
  - Lighting

Means

- Living Labs (LL) stand in between the laboratory and the “real world” scales, with deep engagement of users operating in an environment equipped to monitor and meter a number of parameters
- PECS performance are assessed in 2 LL in Italy: Rome and Perugia

Method

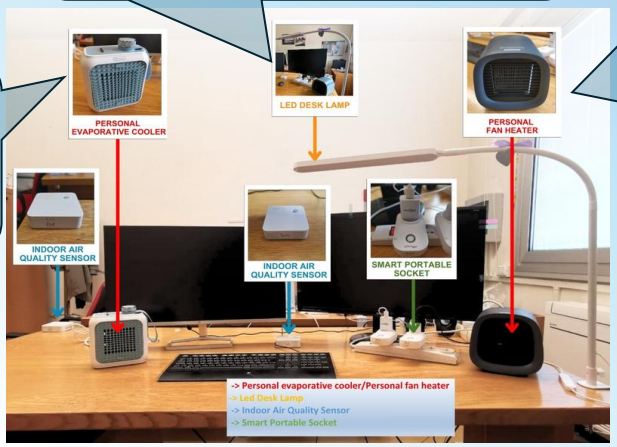
1. Preparation phase:
   - ✓ Identification and selection of desk PECS for lighting and thermal energy
   - ✓ Preparation of the questionnaire for subjective assessment
   - ✓ Collection of general data of the LL users
   - ✓ Short training for users: PECS operation and preferences (position and intensity of the lamp, position of the heater – body, hands, feet), explanation of the questionnaire
2. Monitoring phase
   - ✓ Operation modes: standard mode, only PECS and mixed PECS
   - ✓ The latter means use of PECS with relaxed set-points (28°C in summer instead of 26°C, 20°C in winter instead of 22°C)
   - ✓ Duration: at least three weeks in both LLs during winter and summer 2025
   - ✓ Questionnaire to be filled by users twice a day
3. Analysis of IEQ and energy performance

Selected PECS

Lighting PECS: desk led lamps, 11 intensity levels, 12W max. power absorption; the colour temperature has five modes between 3000K and 6000K.

Heating PECS: desk Joule effect fan heather. 360W constant power absorption, change of temperature emission.

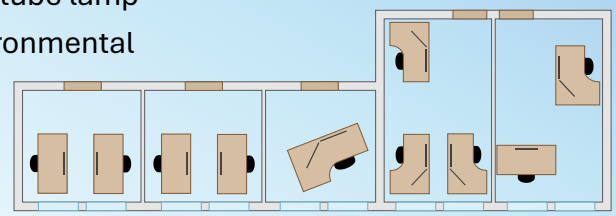
Cooling PECS: evaporative cooler (or simple fan), 4 air velocity, 8W maximum power absorption, high cooling efficiency. Water tank ensure 3/8 hours.



5

LL1 Living Lab University of Perugia

- 3 of 10 rooms (16m^2) of an office building, east oriented
- Permanent workers 7, others on-rotation for monitoring purposes - (mainly students, age 27-36)
- Background heating/cooling: HVAC centralized with ±3°C variation from the set-point temperature variation using the room thermostat
- Background lighting: 16x13W fluorescent tube lamp
- Continuous monitoring of the indoor environmental conditions and of PECS energy use
- Users tested the rooms with and without PECS

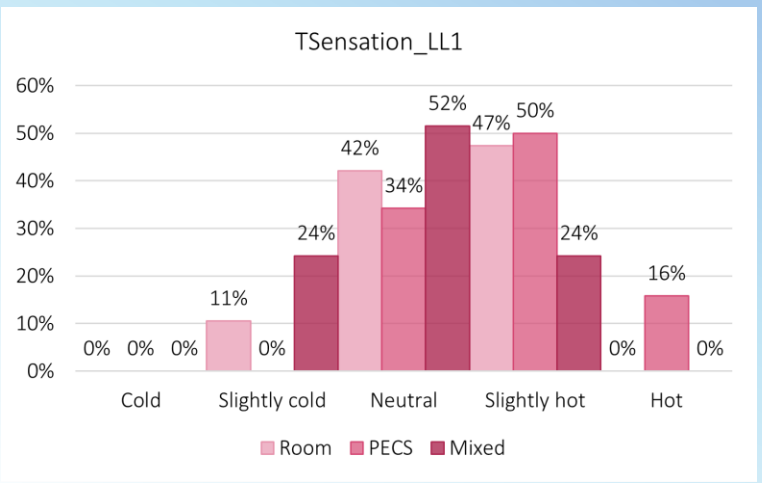


6

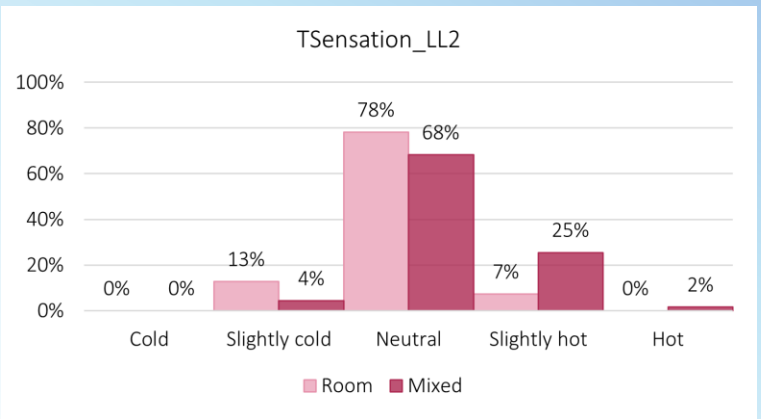
LL2 Living Lab ENEA, Rome

- 11 rooms (17m^2) on the same floor of an office building, east or west oriented
- Number of permanent workers 17 (1/2 per room), others on-rotation (median age 49 years)
- Background heating/cooling: room AC units
- Background lighting: 6x18W led lamp
- Smart Building Management System monitor and store all energy and environmental parameters
- Some rooms equipped with PECS, some not, some both

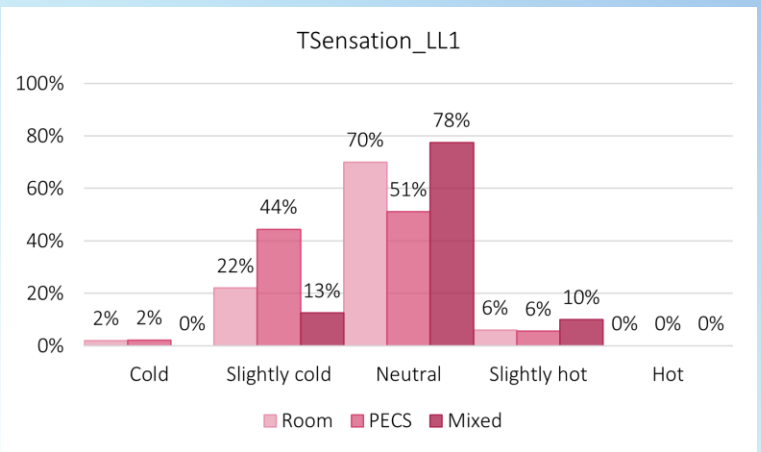
Questionnaire results: thermal sensation @ LL1 in summer



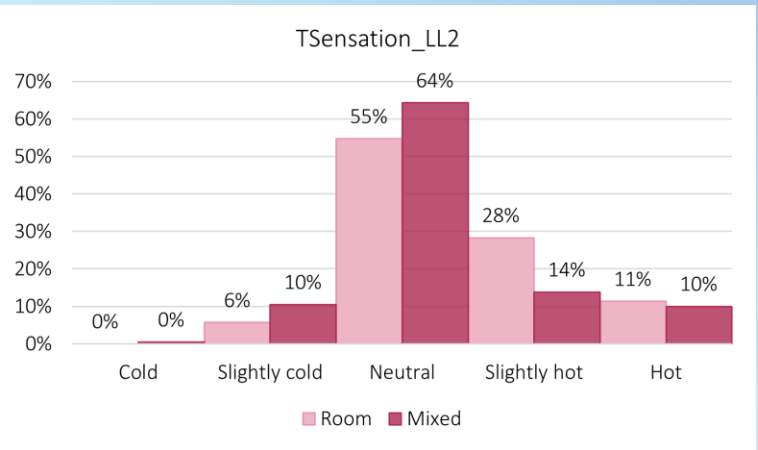
Questionnaire results: thermal sensation @ LL2 in summer



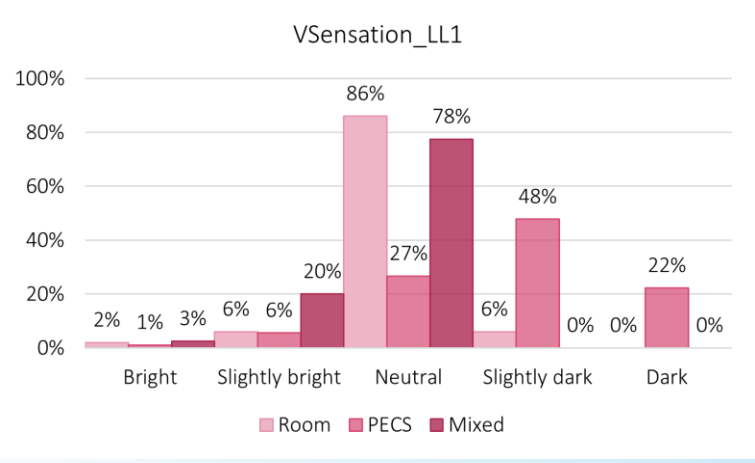
Questionnaire results: thermal sensation @ LL1 in winter



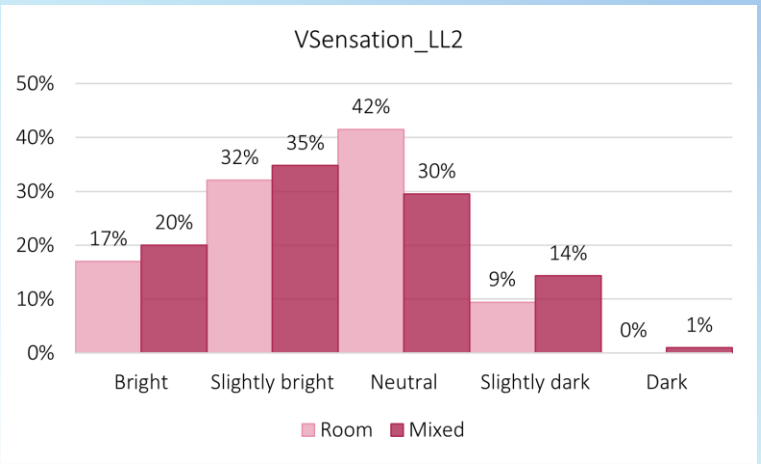
Questionnaire results: thermal sensation @ LL2 in winter



Questionnaire results: visual sensation @ LL1 in winter

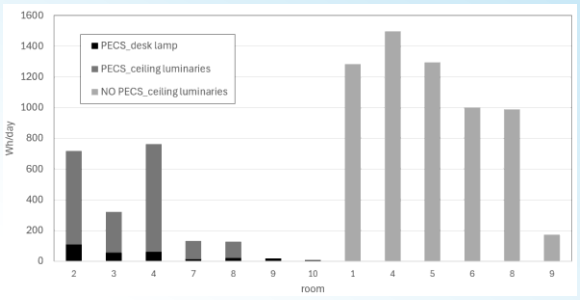


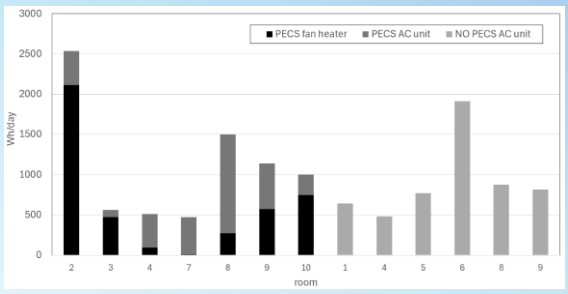
Questionnaire results: visual sensation @ LL2 in winter



Results: energy performance @ LL2 in winter

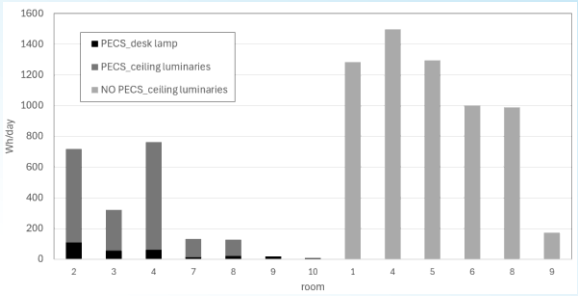
- Winter lighting energy savings about 70%
- Heating energy penalties about 3%

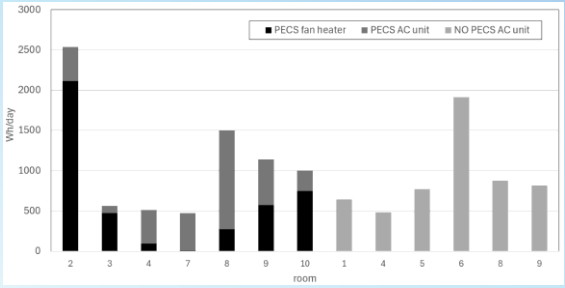




Results: energy performance @ LL2 in winter and summer

- Winter lighting energy savings 70%
- Heating energy penalties 3%
- Summer lighting energy savings 66%
- Cooling energy savings 10%





Conclusions

- Desk PECS for heating, cooling, and lighting tested in LLs (close to real working environment)
- Mixed usage provide adequate comfort conditions, only PECS may not
- Preliminary energy analyses evidence high energy savings for the lighting energy service, and potentially for space cooling
- Heating performance are affected by the low efficiency of the desk fan heater
- Next steps expand the field data by additional monitoring, and combine measured data with simulated ones to generalise current findings

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17

Thanks for your attention!

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18